AF 2161

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

First Named Inventor	: Errol C. Heiman et al.	Appeal No. ---
Appln. No.	: 09/823,079	
Filed	: March 30, 2001	Group Art Unit: 2161
For	: COMPREHENSIVE APPLICATION POWER TESTER	Examiner: Etienne Pierre Leroux
Docket No.	: S01.12-1022	

BRIEF FOR APPELLANT

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I HEREBY CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450, THIS
28th DAY OF APRIL, 2005.
A Rego
PATENT ATTORNEY

Sir:

This is an appeal from an Office Action dated December 1, 2004 in which claims 18 to 37 were finally rejected.

REAL PARTY IN INTEREST

Seagate Technology LLC, a corporation organized under the laws of the state of Delaware, and having offices at 920 Disc Drive, has acquired the entire right, title and interest in and to the invention, the application, and any and all patents to be obtained therefor, as set forth in the Assignment filed with the patent application and recorded on Reel 011684, frame 0375.

RELATED APPEALS AND INTERFERENCES

There are no known related appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

STATUS OF THE CLAIMS

I. Total number of claims in the application.

Claims in the application are: 1-37

II. Status of all the claims.

A. Claims cancelled: 1-17

B.	Claims withdrawn but not cancelled:	---
C.	Claims pending:	18-37
D.	Claims allowed:	---
E.	Claims rejected:	18-37
F.	Claims Objected to:	

III. Claims on appeal

The claims on appeal are: 18-37

STATUS OF AMENDMENTS

An Amendment After Final was filed subsequent to the final rejection. A copy of this Amendment is included as Appendix B.

SUMMARY OF CLAIMED SUBJECT MATTER

In general, the present invention relates to a power testing system that is capable of testing the design of electronic devices by supplying various voltage disturbances, sequences and interruptions to the electronic device.

Some electronic devices (such as disc storage devices) are designed to operate at nominal voltages. Unexpected disturbances often occur in these nominal voltages during the lifetime of the device. The severity and frequency of such disturbances are highly random and can vary based upon a computer power supply capability, local utility quality, climate, operating environment, and other numerous factors. Design of circuitry, for disc storage products, for example, must provide a certain amount of immunity to these disturbances for the products to survive and provide useful service throughout their life. (Page 1, first paragraph of the Background of the Invention section.)

The present invention provides a method and electronic device power testing apparatus 100 (FIG. 1) in which a nominal voltage is applied to electronic components and disturbances are introduced into this nominal voltage to simulate the occurrence of such real world disturbances. Power tester apparatus 100 is capable of testing an electronic device that is configured to

operate using a constant power supply voltage at a nominal power supply voltage. Power tester apparatus 100 includes a power source 107 (FIG. 1) that supplies the constant power supply voltage at the nominal power supply voltage of the electronic device 105 (FIG. 1). A connector 111 (FIG. 1) is coupled to the power source. The connector 111 is adapted to connect the constant power supply voltage to a power supply input on the electronic device 105. Also included, is circuitry (multifunction I/O board 103, variable low disturbance switch 109, etc., shown in FIG. 1) configured to introduce disturbances into the constant power supply voltage applied to the electronic device 105. A disturbance simulates an unexpected change in the nominal power supply voltage. The disturbances introduced into the constant power supply voltage applied to the electronic device 105 are controllable. (Page 4 of the specification.)

DESCRIPTION OF REFERENCES RELIED ON BY THE EXAMINER

Yamamoto, U.S. Pub. No. 2002/0050813 (See Appendix C), relates to a burn-in test method for a semiconductor chip and burn-in apparatus therefor. A burn-in test is performed by imposing current stress to every internal circuit by supplying the internal circuits of a semiconductor chip with a pulse voltage that varies from zero Volts to a burn-in voltage.

Sakamoto, U.S. Patent No. 5,353,254 (See Appendix C), relates to a standardized system for testing semiconductor devices, which may have many different types of pin counts and configurations. Each semiconductor device includes standardized test circuitry. The necessary pins to operate the test circuitry are included in a standardized position on the semiconductor devices relative to the positioning of the semiconductor devices in the test apparatus. Thus a single test apparatus may be utilized to test semiconductor devices having a wide range of pin configurations.

Lee et al., U.S. Patent No. 5,949,671 (See Appendix C),

relates, in general, to power conversion, and more specifically to a DC power supply that may be configured to provide alternative output voltages and a method of operating a DC power supply to provide alternative output voltages.

Lee et al., U.S. Patent No. 4,764,652 (See Appendix C), relates, in general, to a power control device for a high-frequency induced heating cooker, and more particularly to a current control device designed to supply a constant electric power to a work coil of the high-frequency induced heating cooker regardless of any change in the input current and voltage.

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Whether claims 18-37 contain subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Whether claims 18-20, 27-30 and 37 are not anticipated by Yamamoto.

Whether claims 21 and 31 are non-obvious in view of Yamamoto and Sakamoto.

Whether claims 22, 23, 32 and 33 are non-obvious in view of Yamamoto and Lee et al. ('671).

Whether claims 24-26 and 34-36 are non-obvious in view of Yamamoto and Lee et al. ('652).

ARGUMENT

I. Rejection of claims under 35 U.S.C. §112

In the final Office Action dated December 1, 2004, claims 18-37 were rejected under 35 U.S.C. §112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Specifically, the Examiner noted that the language in claims 18

and 28, related to making a "random" disturbance in the nominal power supply, is not described in the specification.

In an Amendment After final (Appendix B), which was filed on February 1, 2005, claims 18 and 28 were amended to remove the language related to making a "random" disturbance in the nominal power supply. However, in an Advisory Action, which was mailed on March 1, 2005, the Examiner indicated that the proposed amendments to claims 18 and 28 would not be entered because they raise new issues that would require further consideration and/or search. Further, in the Advisory Action, the Examiner noted that the proposed Amendments broaden independent claims 18 and 28.

Appellants respectfully point out that if, as indicated by the Examiner, "random" disturbance is not contained in the specification, then it is not a part of the invention. Therefore, removal of this language (which the Examiner suggests is not a part of the invention) from claims 18 and 28 would not constitute broadening the scope of the claimed invention as suggested by the Examiner in the Advisory Action. Since the statements in the final Office Action contradict the statements in the Advisory Action, the §112 rejection is either incorrect or should result in the entry of the Amendment After Final and subsequent withdrawal of the rejection.

II. Rejection of claims under 35 U.S.C. §102(e)

In section 1 of the Office Action, the Examiner rejected claims 18-20, 27-30 and 37 under 35 U.S.C. §102(e) based upon Yamamoto.

A claim is anticipated only if each and every element as set forth in the claim is found, . . ., in a single prior art reference. Verdegaal Bros. V. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); M.P.E.P. §2131. The identical invention must be shown in as complete detail as is contained in the . . . claim. Richardson v. Suzuki

Motor Co., 868 F.2d 1226, 1236, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989); M.P.E.P. §2131.

The above requirements for anticipation are not met in the rejection of claims 18-20, 27-30 and 37 under 35 U.S.C. §102(e), based upon Yamamoto, provided by the Examiner.

A. Argument for claim 18

Independent claim 18 states that the electronic device under test is configured to operate using a constant voltage at a nominal power supply voltage. A power source supplies the constant power supply voltage at the nominal power supply voltage.

As noted earlier, some circuitry is designed to operate at nominal voltages. The present invention introduces disturbances which simulate unexpected deviations from these nominal voltages. As mentioned above, the severity and frequency of such disturbances are highly random and can vary based upon a computer power supply capability, local utility quality, climate, operating environment, and other numerous factors. Design of circuitry, such as for disc storage products, must provide a certain amount of immunity to these disturbances for the products to survive and provide useful service throughout their life. The present invention provides a method and electronic device power testing apparatus in which a nominal voltage is applied to electronic components and disturbances are introduced into this nominal voltage to simulate the occurrence of such real world disturbances.

As noted above, independent claim 18 includes "a power source supplying the constant power supply voltage at the nominal power supply voltage of the electronic device." Yamamoto, which discloses a burn-in test method for a semiconductor chip and burn-in test apparatus therefor, does describe applying various voltage levels. However, the Yamamoto reference does not discuss application (using a power source) of the nominal supply voltage for the circuitry which is being tested. Therefore, the Yamamoto

reference does not satisfy the requirement for anticipation of a claim set forth in Richardson, with regard to claim 18.

Further, claims 18 includes "circuitry configured to introduce disturbances into the power supply voltage . . . configured to simulate an unexpected change in the nominal supply voltage." As discussed in the instant application, unexpected or random voltage disturbances can shorten the life expectancy of electronic devices. Yamamoto shows the application of periodic (non-random) pulses to semiconductor memory circuitry. However, the Yamamoto reference does not discuss unexpected changes in a nominal power supply voltage.

For the above reasons, it is clear that the rejection of claim 18 based upon Yamamoto does not meet the earlier listed requirements for anticipation.

B. Argument for claim 28

Independent claim 28, which is directed to a method for testing an electronic device of the type which is powered by a constant power supply voltage at a nominal power supply voltage, includes elements that are substantially similar to the above-noted elements of claim 18. Thus, for the reasons stated above, the elements of claim 28 are not described in Yamamoto. Therefore, the Yamamoto reference does not satisfy the requirements for anticipation of a claim set forth in Richardson, with regard to claim 28.

C. Argument for dependent claims 19-20, 27, 29-30 and 37

Claims 19-20, 27, 29-30 and 37 are dependent claims that ultimately depend for independent claims 18 or 28, which are both believed to be patentable over the prior art of record for the reasons discussed above. Further, the dependent claims set forth numerous elements not shown or suggested in the Yamamoto reference. For example, dependent claim 27 includes "the disturbance comprises a voltage sequence applied during powering up of the electronic device." The final Office Action suggests

that the Abstract of Yamamoto shows this element. However, the Abstract of Yamamoto, which briefly lists features of a burn-in test method and apparatus for a semiconductor chip, includes nothing about a voltage sequence applied during "powering up" of the electronic device, as required by claim 27. Further, dependent claim elements such as "introducing unexpected variations in a nominal power supply voltage in which a rising pulse having a maximum voltage which is controllable" (claims 19 and 29), "a low going pulse having a minimum voltage" (claims 20 and 30), etc., are also not disclosed in Yamamoto.

In conclusion, claims 18-20, 27-30 and 37 have significant distinguishable features over Yamamoto and are therefore patentable.

III. Rejection of claims under 35 U.S.C. §103(a)

In section 3 of the final Office Action, claims 21 and 31 were rejected under 35 U.S.C. § 103 based upon Yamamoto in view of Sakamoto, claims 22, 23, 32 and 33 were rejected based upon Yamamoto in view of Lee et al. ('671), and claims 24-26 and 34-36 were rejected based upon Yamamoto in view of Lee et al. ('652).

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all of the claim limitations. In re Vaeck, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. §2143.

Under these criteria, the final Office Action fails to establish a *prima facie* case of obviousness of claims 21-26 and 31-36 based on the cited prior art.

Claims 21-26 ultimately depend from independent claim 18 and claims 31-36 ultimately depend from independent claim 28.

For reasons included above, the earlier-noted elements of independent claims 1 and 18 and not disclosed in the Yamamoto reference. The remaining references (Sakamoto, Lee et al. ('671) and Lee et al. ('652)) do not overcome the deficiencies of the Yamamoto reference. As such, dependent claims 21-26 and 31-36 are not obvious over the cited art.

Further, Lee et al. ('671), which discloses a power supply with re-configurable outputs for different output voltages, and Lee et al. ('652), which discloses a power control device for a high-frequency induced heating cooker, are unrelated to power testing of electronic devices.

In conclusion, since none of the reference taken alone or in combination teach or suggest the claimed invention, the Examiner has failed to support a *prima facie* conclusion of obviousness (by not satisfying the third criterion for a *prima facie* conclusion of obviousness set forth in Vaeck) with regard to the pending claims. Furthermore, the Examiner provided no evidentiary basis for modifying the cited references to arrive at the claimed invention. Therefore, claims 21-26 and 31-36 are allowable.

CONCLUSION

For the reasons discussed above, Appellants respectfully submit that independent claims 18 and 28 are patentable over the prior art of record. Also, Appellants respectfully submit that claims 19-27 and 29-37 are allowable as well at least by virtue of their dependency from allowable independent claims 18 and 28, respectively. Thus, Appellants respectfully request that the Board reverse the Examiner and find all pending claims allowable.

Respectfully submitted,
WESTMAN, CHAMPLIN & KELLY, P.A.

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Appendix A

Claims 1-17 (canceled).

18. A power tester apparatus for testing an electronic device, the device configured to operate using a constant power supply voltage at a nominal power supply voltage, the apparatus comprising:

a power source supplying the constant power supply voltage at the nominal power supply voltage of the electronic device;

a connector coupled to the power source, the connector adapted to connect the constant power supply voltage to a power supply input on the electronic device;

circuitry configured to introduce disturbances into the constant power supply voltage applied to the electronic device, a disturbance configured to simulate an unexpected change in the nominal power supply voltage;

wherein the disturbances introduced into the constant power supply voltage applied to the electronic device are controllable.

19. The apparatus of claim 18 wherein the disturbance is a rising pulse having a maximum voltage which is controllable.

20. The apparatus of claim 18 wherein the disturbance is a low-going pulse having a minimum voltage being less than the voltage.

21. The apparatus of claim 18 wherein the constant power supply voltage is selected from the group of voltages consisting of +5 VDC and +12 VDC.

22. The apparatus of claim 18 further comprising an additional

power source supplying an additional voltage wherein the additional power source is adapted to connect the additional voltage to an additional connector.

23. The apparatus of claim 22 wherein the additional voltage is + 24 VDC.

24. The apparatus of claim 18 including a manually operated user interface used to control the disturbances.

25. The apparatus of claim 18 wherein the disturbance is at least one pulse having a duration and a magnitude which are controllable.

26. The apparatus of claim 18 wherein the disturbance is a plurality of pulses and a frequency and a number of pulses in the plurality of pulses are controllable.

27. The apparatus of claim 18 wherein the disturbance comprises a voltage sequence applied during powering up of the electronic device.

28. A method for testing an electronic device of the type which is powered by a constant power supply voltage at a nominal power supply voltage, the method comprising:

supplying the constant power supply voltage at the nominal power supply voltage of the device from a voltage source;

coupling the constant power supply voltage to a connector, the connector adapted to connect the constant power supply voltage to a power supply input of the electronic device;

introducing a disturbance into the constant power supply

voltage applied to the power supply input of the electronic device; and

controlling the disturbance introduced into the constant power supply voltage applied to the power supply to simulate an unexpected change in the nominal power supply voltage.

29. The method of claim 28 wherein the disturbance is a rising pulse having a maximum voltage which is controllable.

30. The method of claim 28 wherein the disturbance is a low-going pulse voltage which is controllable.

31. The method of claim 28 wherein the nominal voltage is selected from the group of voltages consisting of +5 VDC and +12 VDC.

32. The method of claim 28 further comprising:

supplying an additional voltage from an additional power source, the additional power source adapted to connect the additional voltage to an additional connector.

33. The method of claim 32 wherein the additional voltage is + 24 VDC.

34. The method of claim 28 including receiving control parameters from the user interface.

35. The method of claim 28 wherein the disturbance is a pulse having a controllable duration and a controllable magnitude.

36. The method of claim 28 wherein the disturbance is a plurality of pulses and a number of the plurality of pulses are

controllable.

37. The method of claim 28 further including providing a 0 VDC voltage for a preselected duration of time after the voltage is coupled to the connector.

Appendix B

Amendment After final filed on February 1, 2005

Appendix C

Yamamoto, U.S. Pub No. 2002/0050813, May 2002

Sakamoto, U.S. Patent No. 5,353,254, October 1994

Lee et al., U.S. Patent No. 5,949,671, September 1999

Lee et al., U.S. Patent No. 4,764,652, August 1988

Appendix D

Verdegaal Bros. V. Union Oil Co. of California, 2 U.S.P.Q.2d 1051, 1053 (Fed. Cir. 1987).

Richardson v. Suzuki Motor Co., 9 U.S.P.Q.2d 1913, 1920 (Fed. Cir. 1989).

In re Vaeck, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

RESPONSE UNDER 37 C.F.R. § 1.116
EXPEDITED PROCEDURE
EXAMINING GROUP 2100

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	: Errol C. Heiman	
Appln. No.	: 09/823,079	
Filed	: March 30, 2001	Group Art Unit: 2161
For	: COMPREHENSIVE APPLICATION POWER TESTER	Examiner: E. Leroux
Docket No.	: STL 9524/S01.12-1022	

AMENDMENT AFTER FINAL

I HEREBY CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450, THIS

1 DAY OF May, 2005.

PATENT ATTORNEY

Mail Stop AF
Commissioner for Patents
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Alexandria, VA 22313-1450

Sir:

This is in response to the Office Action mailed on December 1, 2004. Please amend the above-identified application as follows.

AMENDMENT TO THE CLAIMS

Claims 1-17 (canceled).

18. (currently amended) A power tester apparatus for testing an electronic device, the device configured to operate using a constant power supply voltage at a nominal power supply voltage, the apparatus comprising:

a power source supplying the constant power supply voltage at the nominal power supply voltage of the electronic device;

a connector coupled to the power source, the connector adapted to connect the constant power supply voltage to a power supply input on the electronic device;

circuitry configured to introduce disturbances into the constant power supply voltage applied to the electronic device, a disturbance configured to simulate an unexpected ~~and random~~ change in the nominal power supply voltage;

wherein the disturbances introduced into the constant power supply voltage applied to the electronic device are controllable.

19. (previously presented) The apparatus of claim 18 wherein the disturbance is a rising pulse having a maximum voltage which is controllable.

20. (previously presented) The apparatus of claim 18 wherein the disturbance is a low-going pulse having a minimum voltage being less than the voltage.

21. (previously presented) The apparatus of claim 18 wherein the constant power supply voltage is selected from the group of voltages consisting of +5 VDC and +12 VDC.

22. (previously presented) The apparatus of claim 18 further comprising an additional power source supplying an additional voltage wherein the additional power source is adapted to connect the additional voltage to an additional connector.

23. (previously presented) The apparatus of claim 22 wherein the additional voltage is + 24 VDC.

24. (previously presented) The apparatus of claim 18 including a manually operated user interface used to control the disturbances.

25. (previously presented) The apparatus of claim 18 wherein the disturbance is at least one pulse having a duration and a magnitude which are controllable.

26. (previously presented) The apparatus of claim 18 wherein the disturbance is a plurality of pulses and a frequency and a number of pulses in the plurality of pulses are controllable.

27. (previously presented) The apparatus of claim 18 wherein the disturbance comprises a voltage sequence applied during powering up of the electronic device.

28. (currently amended) A method for testing an electronic device of the type which is powered by a constant power supply voltage at a nominal power supply voltage, the method comprising:

supplying the constant power supply voltage at the nominal power supply voltage of the device from a voltage source;

coupling the constant power supply voltage to a connector, the connector adapted to connect the constant power supply voltage to a power supply input of the

electronic device;

introducing a disturbance into the constant power supply voltage applied to the power supply input of the electronic device; and

controlling the disturbance introduced into the constant power supply voltage applied to the power supply to simulate an unexpected ~~and random~~ change in the nominal power supply voltage.

29. (previously presented) The method of claim 28 wherein the disturbance is a rising pulse having a maximum voltage which is controllable.

30. (previously presented) The method of claim 28 wherein the disturbance is a low-going pulse voltage which is controllable.

31. (previously presented) The method of claim 28 wherein the nominal voltage is selected from the group of voltages consisting of +5 VDC and +12 VDC.

32. (previously presented) The method of claim 28 further comprising:

supplying an additional voltage from an additional power source, the additional power source adapted to connect the additional voltage to an additional connector.

33. (previously presented) The method of claim 32 wherein the additional voltage is + 24 VDC.

34. (previously presented) The method of claim 28 including receiving control parameters from the user interface.

35. (previously presented) The method of claim 28 wherein the

disturbance is a pulse having a controllable duration and a controllable magnitude.

36. (previously presented) The method of claim 28 wherein the disturbance is a plurality of pulses and a number of the plurality of pulses are controllable.

37. (previously presented) The method of claim 28 further including providing a 0 VDC voltage for a preselected duration of time after the voltage is coupled to the connector.

REMARKS

This is in response to the Office Action of December 1, 2004. With this response, claims 18 and 28 are amended and all pending claims are presented for reconsideration and favorable action.

In the Examiner's Response No. 1, the Examiner stated that the "features upon which Applicant relies . . . are not recited in the rejected claim(s)." It is believed that the independent claims are patentably distinct from the cited reference because they include, for example, "a power source supplying the constant power supply voltage at the nominal power supply voltage of the electronic device" and, "circuitry configured to introduce disturbances into the power supply voltage . . . configured to simulate an unexpected change in the nominal supply voltage." As stated in the prior Amendment, "The Yamamoto reference does not appear to discuss application of a nominal supply voltage as set forth in the pending claims. Further still, the Yamamoto reference does not appear to discuss introduction of a disturbance configured to simulate an unexpected change in the nominal power supply voltage." For these reasons, it is believed that the rejections to the claims can be withdrawn.

Further, in the Examiner's Response No. 2, the Examiner is objecting to the wording related to "random." That language has been deleted from the claims. In that light, it is noted that the Yamamoto reference does not include the introduction of disturbances which are "configured to simulate an unexpected change in the nominal power supply voltage." Thus, it is believed that the rejections may be withdrawn. In connection with the dependent claims, it is noted in the Examiner's Response No. 3, the Examiner again raised objections related to the use of the "random" language introduced into the claims with the last Amendment. As discussed above, that language has been deleted. It is believed that Applicant's remarks previously set forth related

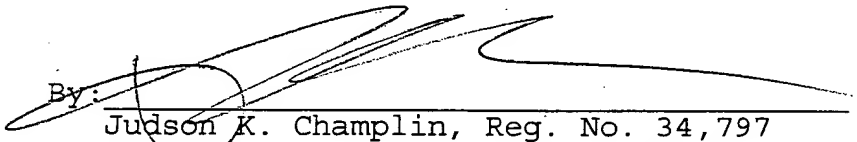
to the dependent claims remain applicable. The dependent claims include introducing unexpected variations in a nominal power supply voltage in which a rising pulse having a maximum voltage which is controllable, a low going pulse having a minimum voltage, constant power supply voltages at 5 and 12 volts DC, connection through an additional voltage connector, the additional voltage connector 24 volts DC, a manually operated user interface to control the disturbances, at least one pulse having a duration and magnitude which are controllable, a frequency of pulses which is controllable or a power up sequence which is controllable. Thus, it is believed that these dependent claims, when read together with the independent claims, are also patentably distinct from the reference.

In view of the above amendments and remarks, it is believed that the present application is in condition for allowance. Consideration and favorable action are respectfully requested.

The Director is authorized to charge any fee deficiency required by this paper or credit any overpayment to Deposit Account No. 23-1123.

Respectfully submitted,

WESTMAN, CHAMPLIN & KELLY, P.A.



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US 20020050813A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2002/0050813 A1

YAMAMOTO (43) Pub. Date: May 2, 2002

(54) BURN-IN TEST METHOD FOR A SEMICONDUCTOR CHIP AND BURN-IN TEST APPARATUS THEREFOR

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(21) Appl. No.: 09/309,907

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(30) Foreign Application Priority Data

Dec. 7, 1998 (JP) 10-346829

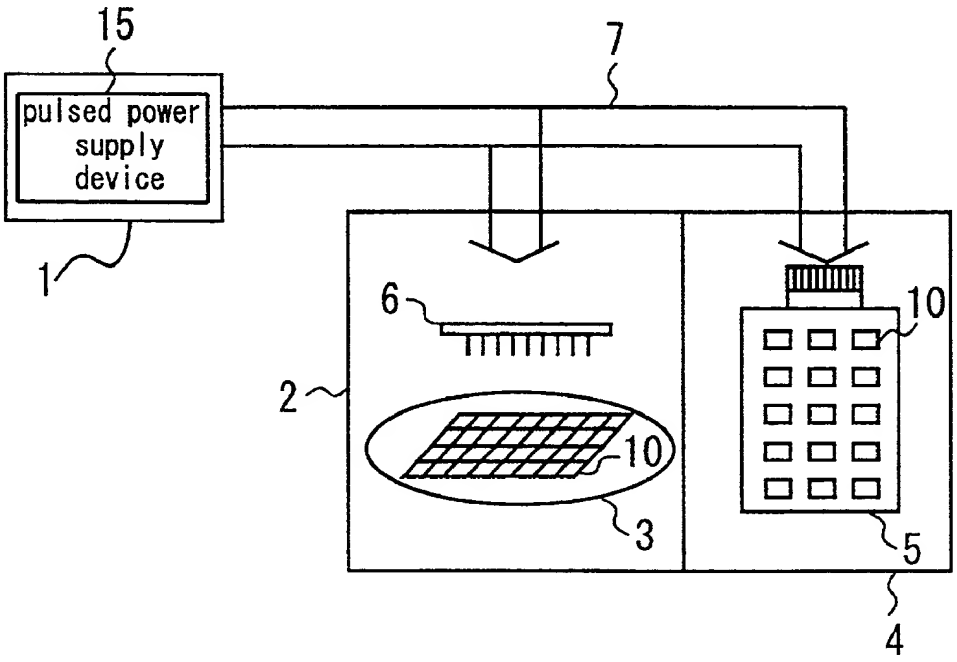
Publication Classification

(51) Int. Cl.[7] G01R 1/00

(52) U.S. Cl. 324/158.1

(57) ABSTRACT

A burn-in test method and apparatus and a semiconductor chip to be used in a burn-in test method that allow current stress to be imposed on every circuit node by varying a power supply voltage in pulse form, and thereby enables an efficient burn-in test. A burn-in test is performed efficiently by imposing current stress to every internal circuit by supplying the internal circuits of a semiconductor chip with a pulse Vcc voltage that varies from 0 V to a burn-in voltage Vbi. The burn-in test time can further be shortened by varying the Vcc voltage in pulse form in a range from a voltage that is higher than or equal to the threshold voltage Vth to the burn-in voltage Vbi or by setting the pulse waveform of the Vcc voltage in such a manner that a high-voltage period T_H is longer than a low-voltage period T_L.



Appendix C

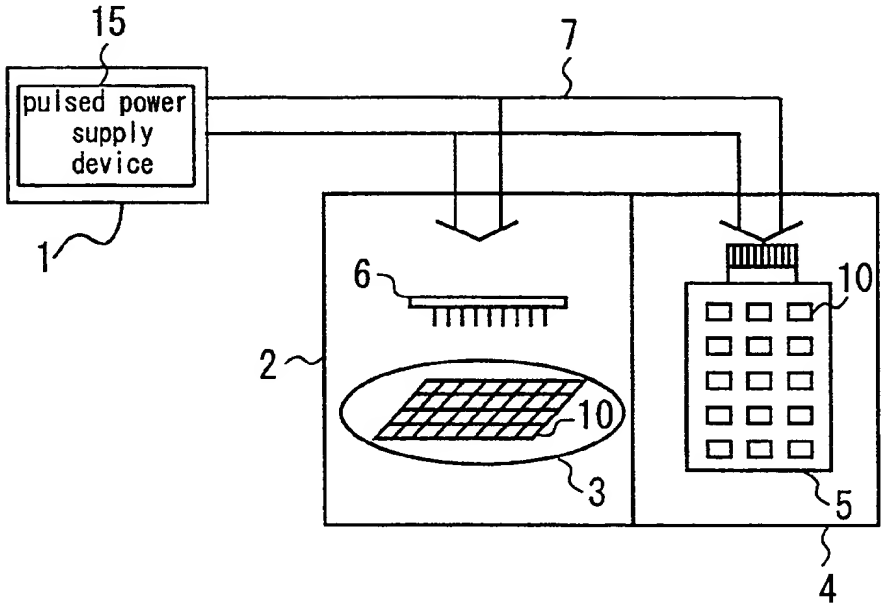
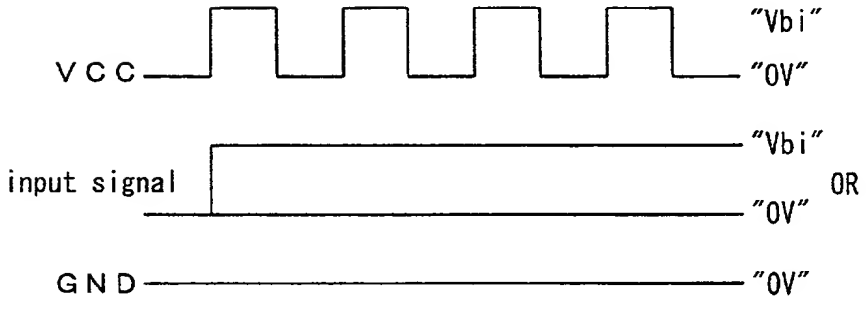

15
pulsed power supply device
1
7
6
2
10
3
10
5
4

FIG. 1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"0V"
input signal
"Vbi"
"0V"
OR
GND
"0V"

FIG. 2

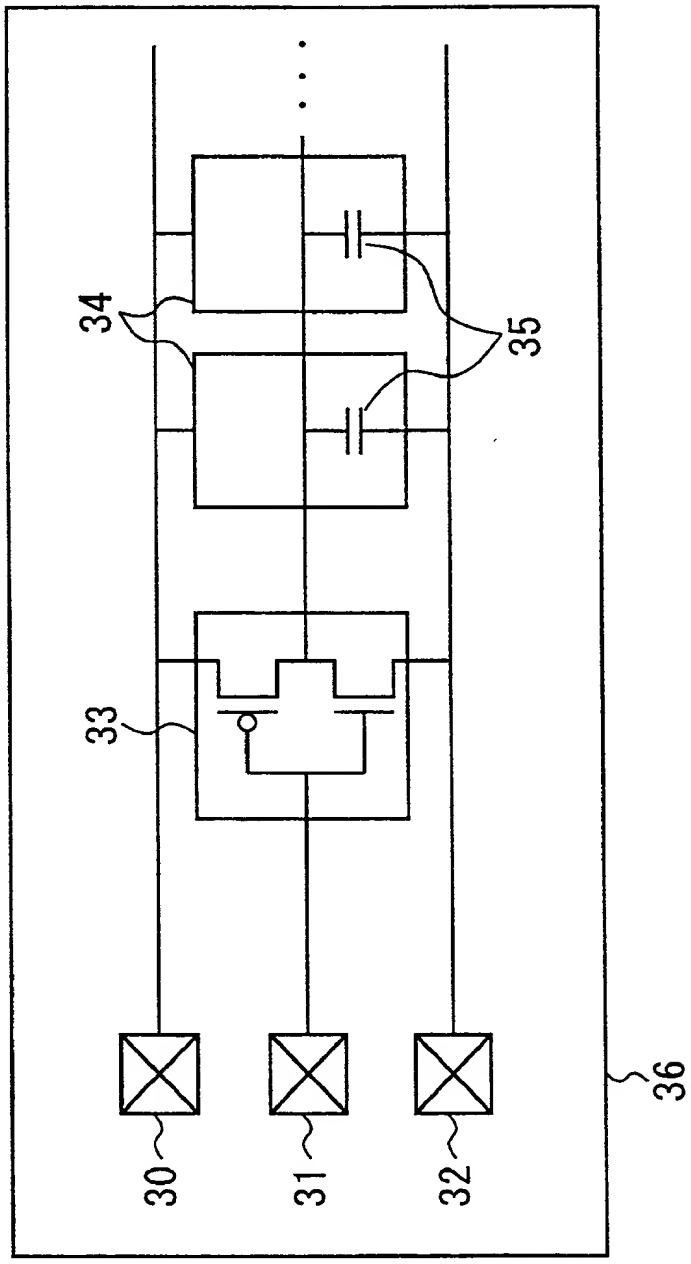

FIG. 3

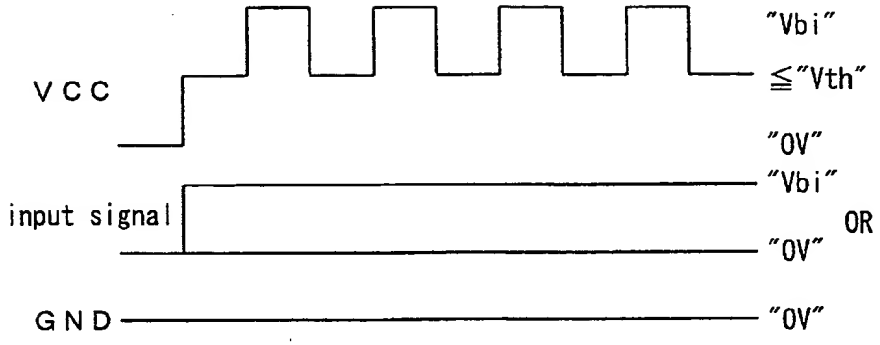
"Vbi"
≦"Vth"
VCC
"0V"
"Vbi"
input signal
OR
"0V"
GND
"0V"

FIG. 4

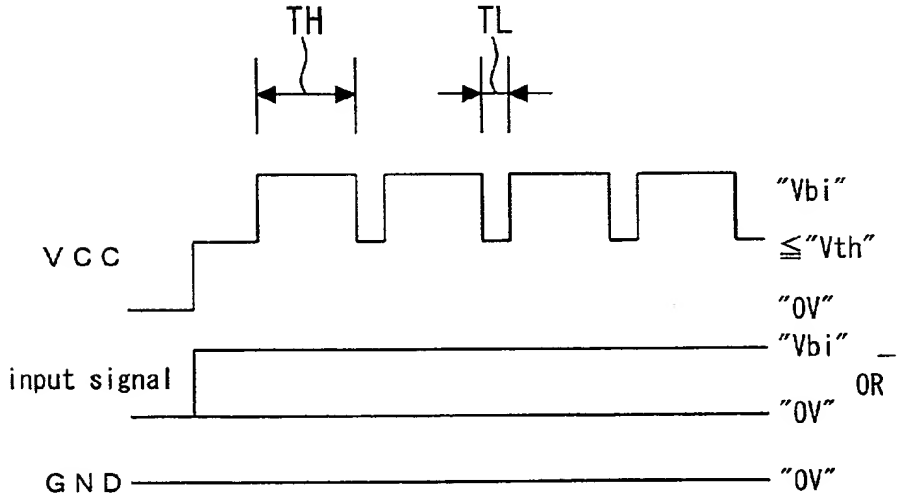
TH
TL
"Vbi"
≦"Vth"
VCC
"0V"
"Vbi"
input signal
OR
"0V"
GND
"0V"

FIG. 5

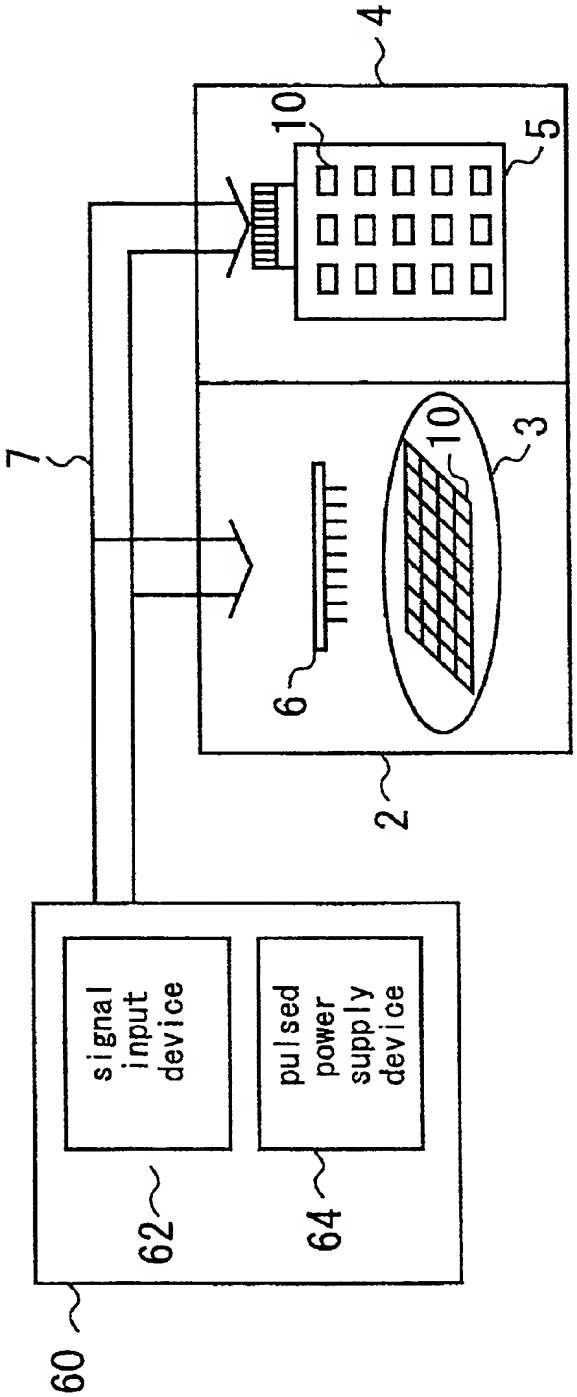
4
10
5
7
10
3
6
2
signal input device
pulsed power supply device
62
64
60

FIG. 6

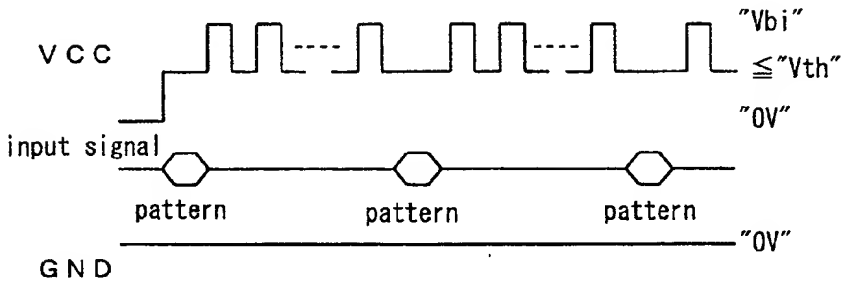
VCC
"Vbi"
≦"Vth"
"0V"
input signal
pattern
pattern
pattern
"0V"
GND

FIG. 7

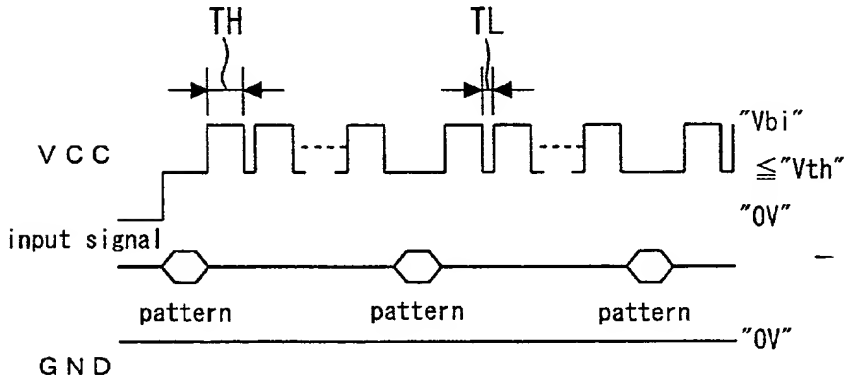
TH
TL
VCC
"Vbi"
≦"Vth"
"0V"
input signal
pattern
pattern
pattern
"0V"
GND

FIG. 8

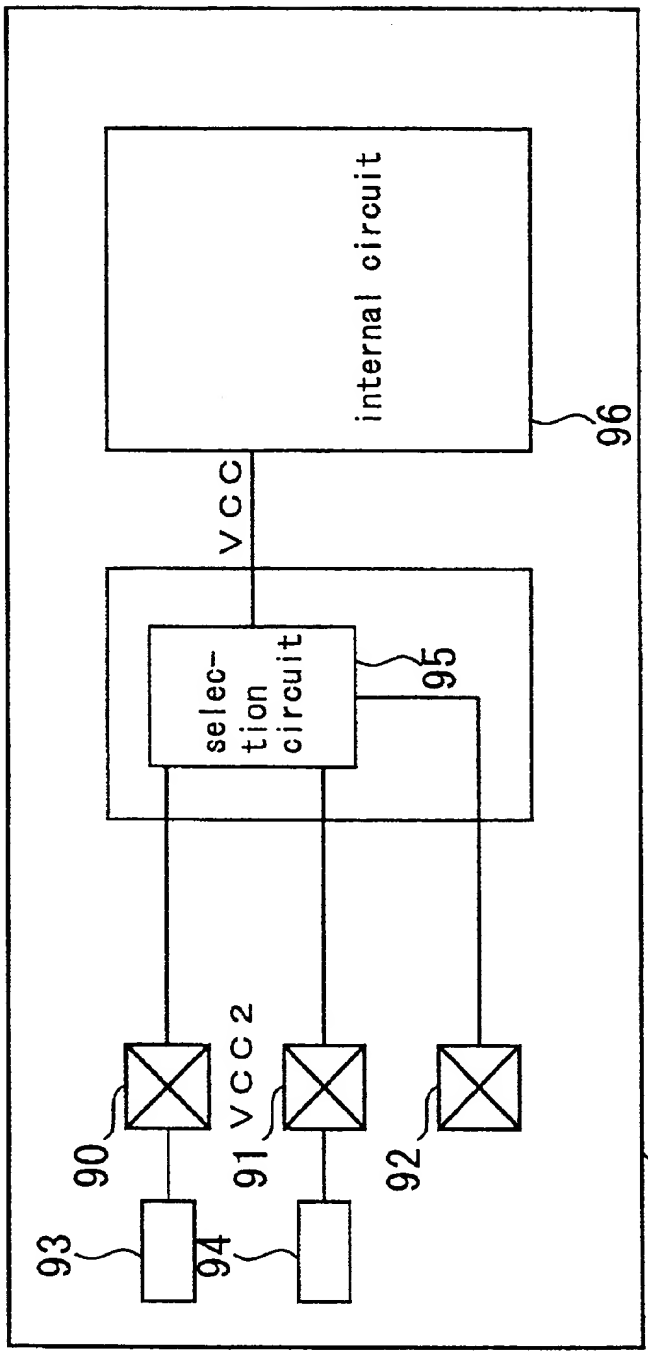
internal circuit
96
VCC
selec-
tion
circuit
95
VCC2
90
91
92
93
94
97

FIG. 9

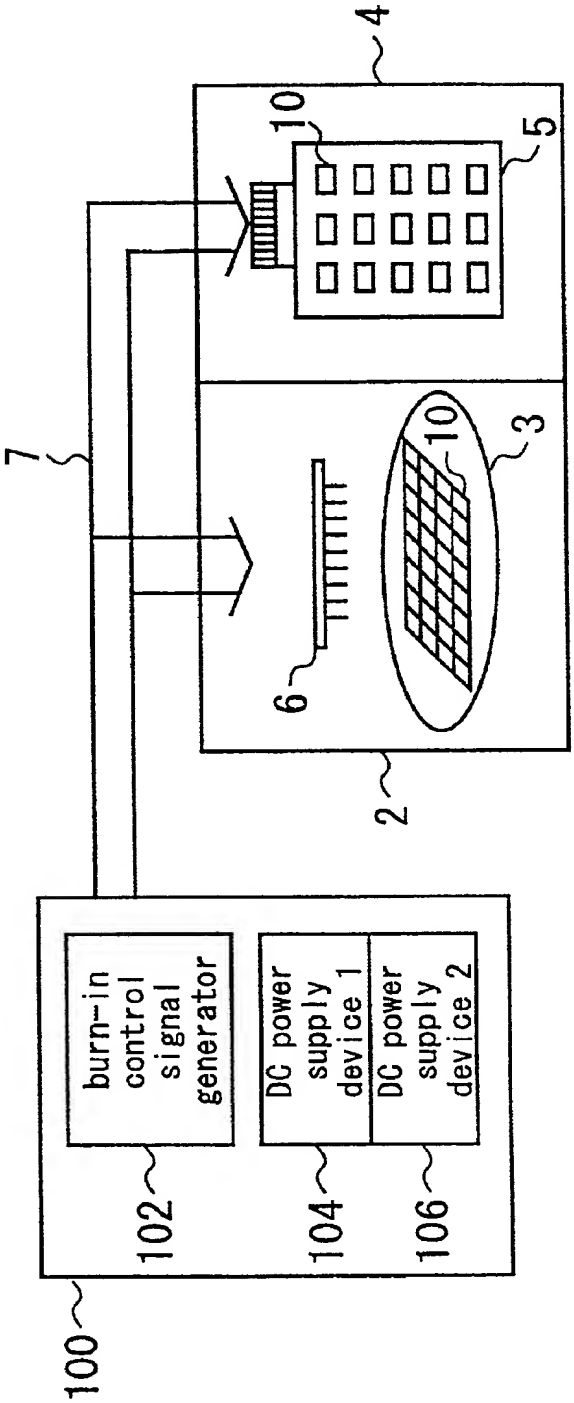
4
10
5
7
10
3
6
2
burn-in control signal generator
DC power supply device 1
DC power supply device 2
102
104
106
100

FIG. 10

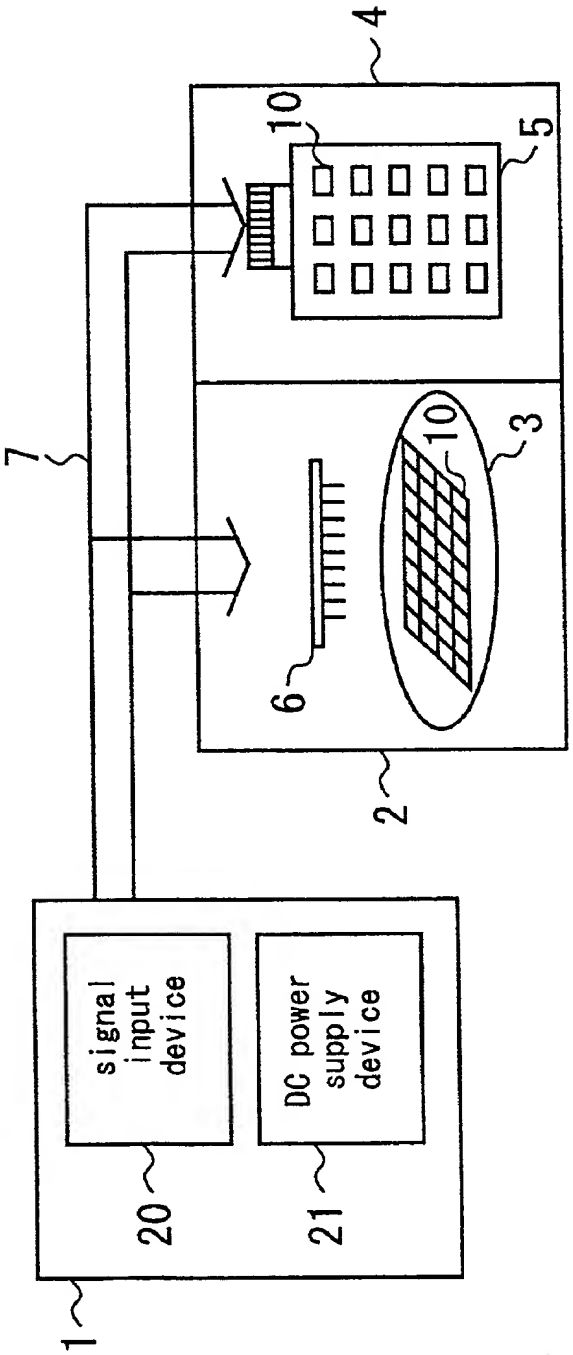

FIG. 11 (PRIOR ART)

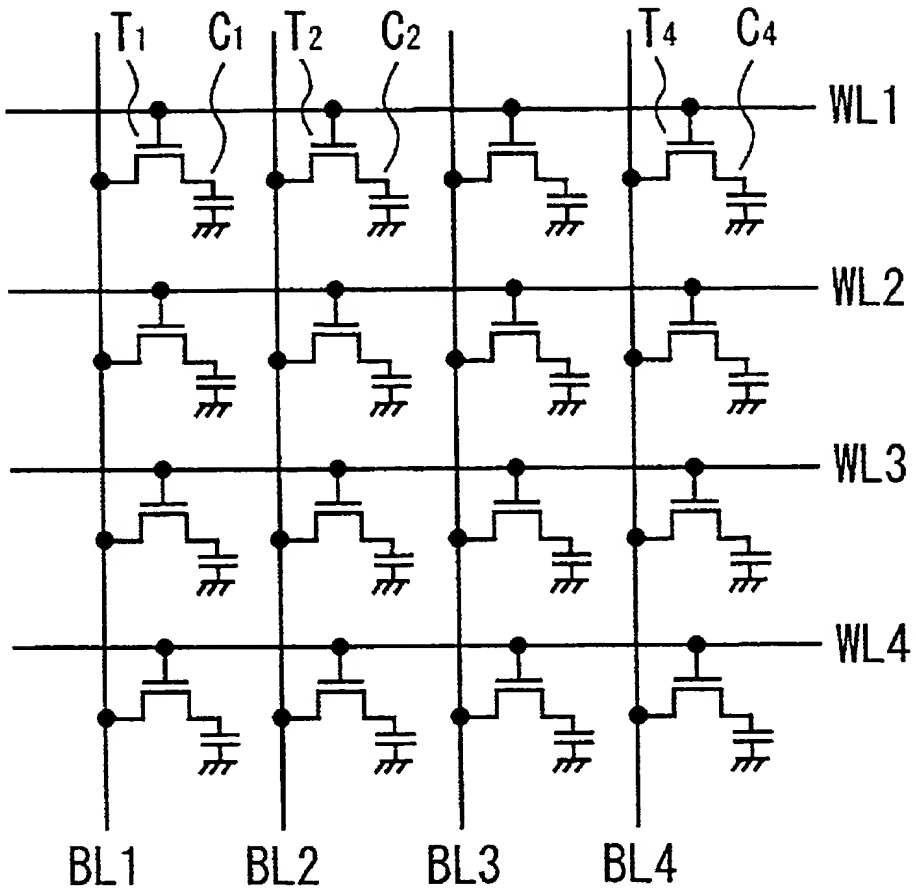

FIG. 12 (PRIOR ART)

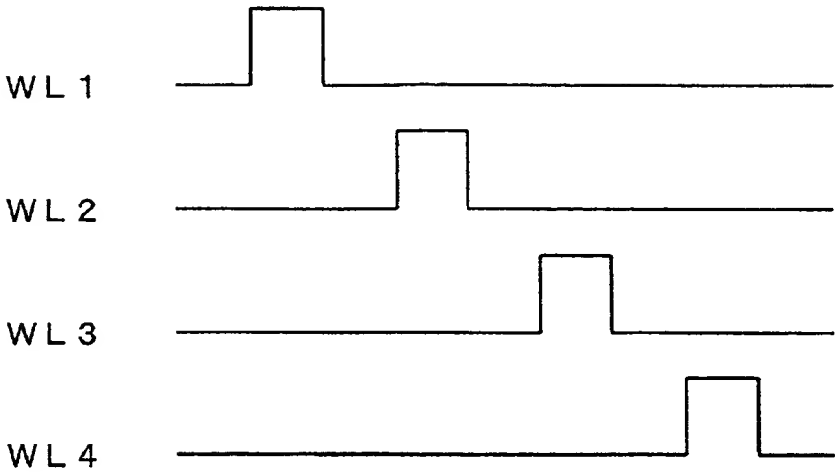

FIG. 13 (PRIOR ART)

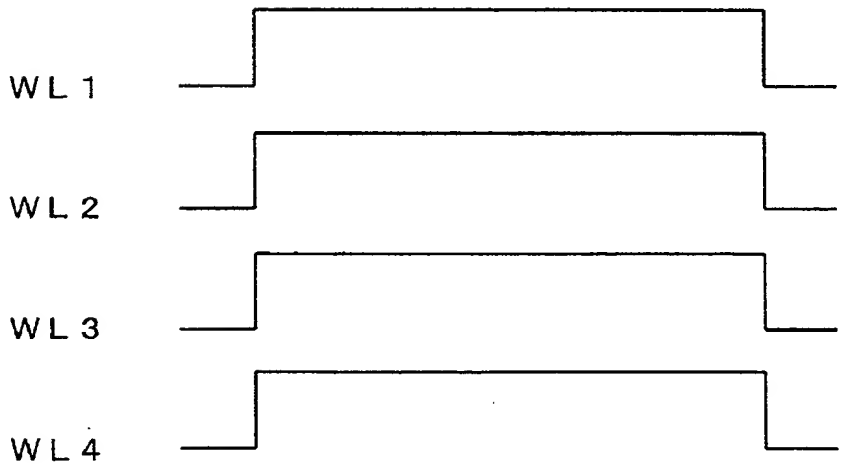

FIG. 14 (PRIOR ART)

BURN-IN TEST METHOD FOR A SEMICONDUCTOR CHIP AND BURN-IN TEST APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a burn-in test method for a semiconductor chip, a burn-in test apparatus, and a semiconductor chip to be used in a burn-in test method.

[0003] 2. Description of Related Art

[0004] The burn-in test of a semiconductor chip is an accelerated life test for screening semiconductor chips having an initial failure or semiconductor chips that are out of the distribution range of a variation in the quality of manufacture by applying, to semiconductor chips, higher voltage, higher temperature stress than in actual use conditions.

[0005] In a conventional burn-in test method, first, after a wafer test, non-defective devices are subjected to assembling and rendered in a package-level state in which each device is sealed in a ceramic package or a plastic package. Then, a burn-in test is performed in such a manner that in a thermostatic chamber a number of chips are placed on a burn-in board and burn-in stress is imposed on those chips en bloc. There is another type of burn-in test method that is performed in a wafer-level state. In this burn-in test method, stress is imposed on non-defective devices in a wafer state, that is, before being subjected to assembling and sealed in a package.

[0006] **FIG. 11** shows a conventional burn-in test apparatus. In **FIG. 11**, reference numeral **1** denotes a burn-in apparatus having a signal input device **20** and a DC power supply device **21**; **2**, a prober; **3**, a wafer to be mounted on a hot chuck (not shown) of the prober **2**; **10**, semiconductor chips formed on the wafer **3**; **6**, a probe card to be connected to the semiconductor chips **10**; **4**, a thermostatic chamber; **5**, a burn-in circuit board provided in the thermostatic chamber **4**; and **7**, power/signal lines that connect the burn-in apparatus **1** to the prober **2** and the burn-in circuit board **5**. In this specification, the entire apparatus constituted of the burn-in apparatus **1**, the prober **2**, the thermostatic chamber **4**, and the power/signal lines **7** is called a burn-in test apparatus.

[0007] A wafer burn-in test is performed by supplying power supply voltages and a signal from the burn-in apparatus **1** to the semiconductor chips **10** on the wafer **3** via the power/signal lines **7** that are connected to the probe card **6**. A package burn-in test is performed in such a manner that the semiconductor chips **10** are mounted on the burn-in circuit board **5** and power supply voltages and a signal are supplied via the power/signal lines **7**.

[0008] **FIG. 12** is a circuit diagram of a DRAM memory cell circuit. As shown in **FIG. 12**, each DRAM memory cell is composed of a word line WL1 or the like, a bit line BL1 or the like, a switching transistor T1 or the like, and a memory capacitor C1 or the like.

[0009] **FIG. 13** is an example time chart showing waveforms of burn-in stress to be imposed on the DRAM memory cell circuit of **FIG. 12**. As shown in **FIG. 13**, the potentials of the word lines WL1-WL4 are caused to rise one by one in order, whereby stress is imposed on the gate oxide films etc. of the switching transistors T1 etc.

[0010] **FIG. 14** is an example time chart showing waveforms of burn-in stress for causing the potentials of the word lines WL1-WL4 to rise collectively to shorten the evaluation time of a wafer burn-in test. As shown in **FIG. 14**, the degree of acceleration of an accelerated life test can be made higher by increasing the memory cell selection ratio by increasing the number of switching transistors T1 etc. on which stress can be imposed. The selection ratio means the number of selected memory cells per unit time.

[0011] However, random logic devices have a problem that because of a large memory cell selection ratio in an actual operation state, a high degree of acceleration is not expected even if the memory cell selection ratio is increased, unlike the case of memory devices such as the above-described memory cell circuit.

[0012] In logic devices whose operation speeds are now being increased, it is necessary to reinforce screening of current -mode failures in addition to voltage-mode failures. Current stress is imposed in the form of a charge/discharge current when a signal changes from "H" to "L" or from "L" to "H." However, since burn-in test vectors are restricted in the kinds of input patterns and expected value patterns, it is difficult to perform a burn-in test by using a test pattern that enables a charge/discharge operation in every circuit. Therefore, in a burn-in test, a charge/discharge operation occurs only in part of the circuits and there are circuits on which current stress is not imposed. This results in a problem that the burn-in efficiency is not sufficiently high.

SUMMARY OF THE INVENTION

[0013] The present invention has been made to solve the above problems in the art, and an object of the invention is therefore to provide a burn-in test method and apparatus and a semiconductor chip to be used in a burn-in test method that allow current stress to be imposed on every circuit node by varying a power supply voltage in pulse form, and thereby enables an efficient burn-in test.

[0014] According to a first aspect of the present invention, there is provided a burn-in test method for a semiconductor chip, comprising: a pulse voltage supplying step of supplying an inverter circuit in a semiconductor chip with a pulse voltage that is output from a pulsed power supply device and varies in a range from 0 V to a burn-in voltage; a charge/discharge step of charging a load capacitor of an internal circuit of the semiconductor chip by using the pulse voltage if an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor by using the pulse voltage if the input signal is at 0 V; and a step of imposing current stress on the internal circuit by using a current generated in the charge/discharge step.

[0015] According to a second aspect of the present invention, there is provided a burn-in test apparatus comprising: a burn-in apparatus having a pulsed power supply device for supplying a pulse voltage that varies in pulse form in a range from 0 V to a burn-in voltage; and a semiconductor chip that is supplied with the pulse voltage from the pulsed power supply device, wherein the semiconductor chip has an internal circuit and a load capacitor in the internal circuit, the internal circuit being given current stress in such a manner

that a current is caused to flow through the internal circuit by charging the load capacitor when an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor when the input signal is at 0 V.

[0016] According to a third aspect of the present invention, there is provided a burn-in test apparatus comprising: a burn-in apparatus having: a plurality of DC power supply devices for supplying respective DC voltages; and a burn-in control signal generation device for generating a burn-in control signal to be used for selecting one of the DC power supply devices; and a semiconductor chip that is supplied with the DC voltages from the respective DC power supply devices, the semiconductor chip having: a plurality of pulsed power supply devices for supplying respective pulse voltages that vary in pulse form in a range from 0 V to a burn-in voltage; an addition section for generating a plurality of pulse supply voltages by adding the DC voltages to the pulse voltages, respectively; a selection circuit for selecting one of the pulse supply voltages generated by the addition section in accordance with the burn-in control signal; and an internal circuit including a load capacitor, wherein the internal circuit being given current stress in such a manner that a current is caused to flow through the internal circuit by charging the load capacitor by using the selected pulse supply voltage when an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor by using the pulse supply voltage when the input signal is at 0 V.

[0017] According to a fourth aspect of the present invention, there is provided a burn-in test method for a semiconductor chip, comprising: a DC voltage supplying step of supplying DC voltages that are output from a plurality of DC power supply devices, respectively; a pulse voltage supplying step of causing a plurality of pulsed power supply devices in the semiconductor chip to output respective pulse voltages that vary in a range from 0 V to a burn-in voltage; a step of generating a plurality of pulse supply voltages by adding the DC voltages to the pulse voltages, respectively; a step of selecting one of the pulse supply voltages in accordance with a control signal that is input to the semiconductor chip; a charge/discharge step of charging a load capacitor of an internal circuit of the semiconductor chip by using the selected pulse supply voltage when an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor by using the pulse supply voltage when the input signal is at 0 V; and a step of imposing current stress on the internal circuit by using a current generated in the charge/discharge step.

[0018] According to a fifth aspect of the present invention, there is provided a semiconductor chip to be used in a burn-in test method in which a pulse voltage that varies in pulse form in a range from 0 V to a burn-in voltage is supplied, the semiconductor chip having an internal circuit including a load capacitor, the internal circuit being given current stress in such a manner that a current is caused to flow through the internal circuit by charging the load capacitor when an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor when the input signal is at 0 V.

[0019] According to a sixth aspect of the present invention, there is provided a semiconductor chip to be used in a burn-in test method in which the semiconductor chip is supplied with respective DC voltages from a plurality of DC power supply devices, the semiconductor chip comprising: a plurality of pulsed power supply devices for supplying respective pulse voltages that vary in pulse form in a range from 0 V to a burn-in voltage; an addition section for generating a plurality of pulse supply voltages by adding the DC voltages to the pulse voltages, respectively; a selection circuit for selecting one of the pulse supply voltages generated by the addition section in accordance with an input burn-in control signal; and an internal circuit having a load capacitor, the internal circuit being given current stress in such a manner that a current is caused to flow through the internal circuit by charging the load capacitor by using the selected pulse supply voltage if an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor by using the pulse supply voltage if the input signal is at 0 V.

[0020] The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of the embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] **FIG. 1** shows a burn-in test apparatus according to a embodiment 1 of the invention.

[0022] **FIG. 2** is a time chart showing waveforms of power supply voltages and a signal that are supplied from the burn-in apparatus **1** of the embodiment 1.

[0023] **FIG. 3** schematically shows a semiconductor chip circuit to be used in the burn-in test apparatus of the embodiment 1.

[0024] **FIG. 4** is a time chart according to a embodiment 3 of the invention.

[0025] **FIG. 5** is a time chart according to a embodiment 4 of the invention.

[0026] **FIG. 6** shows a burn-in apparatus **60** according to a embodiment 5 of the invention.

[0027] **FIG. 7** is a time chart that is used in changing the internal state of each semiconductor chip **10** by causing the signal input device **62** to supply each semiconductor chip **10** with a test pattern as an input signal.

[0028] **FIG. 8** is a time chart according to a embodiment 7 of the invention.

[0029] **FIG. 9** schematically shows a semiconductor chip circuit according to an embodiment 8 of the invention.

[0030] **FIG. 10** shows a burn-in apparatus **100** for performing a burn-in test on the semiconductor chip **10** of **FIG. 9**.

[0031] **FIG. 11** shows a conventional burn-in test apparatus.

[0032] **FIG. 12** is a circuit diagram of a DRAM memory cell circuit.

[0033] **FIG. 13** is an example time chart showing waveforms of burn-in stress to be imposed on the DRAM memory cell circuit of **FIG. 12**.

[0034] **FIG. 14** is an example time chart showing waveforms of burn-in stress for causing the potentials of the word lines WL1-WL4 to rise collectively to shorten the evaluation time of a wafer burn-in test.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] Embodiments of the present invention will be described below with reference to the accompanying drawings. It is noted that the same reference symbols in the drawings denote the same or corresponding components.

[0036] Embodiment 1

[0037] **FIG. 1** shows a burn-in test apparatus according to a embodiment 1 of the invention. In **FIG. 1**, reference numeral **1** denotes a burn-in apparatus having a pulsed power supply device **15**; **2**, a prober; **3**, a wafer to be mounted on a hot chuck (not shown) of the prober **2**; **10**, semiconductor chips formed on the wafer **3**; **6**, a probe card that supplies power supply voltages and a signal to the semiconductor chips **10** on the wafer **3** from the burn-in apparatus **1** via power/signal lines **7**; **4**, a thermostatic chamber; and **5**, a burn-in circuit board provided in the thermostatic chamber **4**. Reference numeral **10** also denotes semiconductor chips provided on the burn-in circuit board **5**.

[0038] **FIG. 2** is a time chart showing waveforms of power supply voltages and a signal that are supplied from the burn-in apparatus **1** of the embodiment 1. As shown in **FIG. 2**, a GND voltage is fixed at 0 V and an input signal is fixed at 0 V or a burn-in voltage Vbi. A Vcc voltage is a pulse voltage ranging from 0 V to the burn-in voltage Vbi.

[0039] **FIG. 3** schematically shows a semiconductor chip circuit to be used in the burn-in test apparatus of the embodiment 1. As shown in **FIG. 3**, power supply voltages and a signal are supplied, via a Vcc voltage pad **30**, a GND voltage pad **32**, and an input signal pad **31**, respectively, to an inverter circuit **33** and internal circuits **34**. Because the Vcc voltage is supplied in pulse form, a load capacitor **35** that is constituted of a gate capacitance, a wiring capacitance, and a junction capacitance is charged (if the input signal is at Vbi) or discharged (if the input signal is at 0 V) at rises and falls of pulses, whereby a current flows through a wiring that constitutes each internal circuit **34**. Since every internal circuit **34** is supplied with the Vcc voltage and the GND voltage, the supply of the pulse Vcc voltage allows current stress to be imposed on every internal circuit **34**. This enables an efficient burn-in test.

[0040] As described above, the embodiment 1 makes it possible to impose current stress to every internal circuit **34** by supplying the internal circuits **34** with the pulse Vcc voltage ranging from 0 V to the burn-in voltage Vbi, and thereby enables an efficient burn-in test.

[0041] Embodiment 2

[0042] A burn-in test method according to a embodiment 2 of the invention will be described below by using the burn-in apparatus **1** and the semiconductor chip circuit **36** of the embodiment 1 and the time chart of **FIG. 2** showing the waveforms of the power supply voltages and the signal.

[0043] The Vcc voltage is supplied from the pulsed power supply device **15** of the burn-in apparatus **1** to the semiconductor chip circuit **36** so as to be varied in pulse form. The input signal to the semiconductor chip circuit **36** is fixed at the burn-in voltage Vbi or 0 V and the GND voltage is fixed at 0 V. In the semiconductor chip circuit **36**, the received pulse Vcc voltage is supplied to the internal circuits **34** via the inverter circuit **33**. The inverter circuit **33** charges the load capacitor **35** of each internal circuit **34** if the input signal is at Vbi and discharges it if the input signal is at 0 V. As a result, a current flows through the wiring that constitutes each internal circuit **34**. Since every internal circuit **34** is supplied with the Vcc voltage and the GND voltage, the supply of the pulse Vcc voltage allows current stress to be imposed on every internal circuit **34**. This enables an efficient burn-in test.

[0044] A wafer burn-in test can be performed in such a manner that power supply voltages and a signal are supplied from the burn-in apparatus **1** to the semiconductor chips **10** on the wafer **3** via the power/signal lines **7** and the probe card **6**. A package burn-in test can be performed in such a manner that the semiconductor chips **10** are mounted on the burn-in circuit board **5** and power supply voltages and a signal are supplied via the power/signal lines **7**.

[0045] As described above, the embodiment 2 makes it possible to impose current stress to every internal circuit **34** by supplying the internal circuits **34** with the pulse Vcc voltage ranging from 0 V to the burn-in voltage Vbi, and thereby enables an efficient burn-in test.

[0046] Embodiment 3

[0047] **FIG. 4** is a time chart according to a embodiment 3 of the invention. As shown in **FIG. 4**, a burn-in test method according to the embodiment 3 is different from the burn-in test method of the embodiment 2 in that the Vcc voltage that is supplied from the pulsed power supply device **15** of the burn-in apparatus **1** to the semiconductor chip circuit (i.e., the semiconductor chip **10**) is a pulse voltage ranging from a voltage that is higher than or equal to the threshold voltage Vth of the switching transistor T1 or the like to a burn-in voltage Vbi. In the embodiment 2, a certain time is needed for every load capacitor **35** to be charged or discharged when the Vcc voltage falls. In contrast, where the Vcc voltage is higher than or equal to Vth as shown in **FIG. 4**, the load capacitor **35** can be charged and discharged more easily. As a result, the frequency of the pulse voltage can be increased. Therefore, the current stress can be increased, which leads to increase in burn-in efficiency.

[0048] As described above, the embodiment 3 makes it possible to charge and discharge the load capacitor **35** more easily by varying the Vcc input voltage in pulse form in a range from a voltage that is higher than or equal to the threshold voltage Vth of the switching transistor T1 or the like to the burn-in voltage Vbi. As a result, the frequency of the pulse voltage can be increased. Therefore, the current stress can be increased, which leads to increase in burn-in efficiency.

[0049] Embodiment 4

[0050] **FIG. 5** is a time chart according to a embodiment 4 of the invention. As shown in **FIG. 5**, a burn-in test method according to the embodiment 4 is different from the burn-in test method of the embodiment 3 in that the Vcc voltage that is supplied from the pulsed power supply device **15** of the burn-in apparatus **1** to the semiconductor chip circuit (i.e., the semiconductor chip **10**) is such that a

high-voltage period T_H of the pulse Vcc voltage is set longer than a low-voltage period T_L. The embodiment 4 is the same as the embodiment 3 in that the Vcc voltage is a pulse voltage ranging from a voltage that is higher than or equal to the threshold voltage Vth of the switching transistor T1 or the like to a burn-in voltage Vbi. Charge/discharge current stress occurs only in transition periods of rises and falls of Vcc input pulses. Therefore, the voltage stress imposition time can be elongated by increasing the high-voltage period T_H of Vcc input pulses. As a result, the efficiency of a voltage-stress burn-in test can be increased without lowering the efficiency of a current-stress burn-in test, whereby the burn-in test time can be shortened.

[0051] As described above, the embodiment 4 makes it possible to elongate the voltage-stress imposition time by setting the high-voltage period T_H of a Vcc input pulse waveform longer than the low-voltage period T_L. As a result, the efficiency of a voltage-stress burn-in test can be increased without lowering the efficiency of a current-stress burn-in test, whereby the burn-in test time can be shortened.

[0052] Embodiment 5

[0053] **FIG. 6** shows a burn-in apparatus **60** according to a embodiment 5 of the invention. As shown in **FIG. 6**, the burn-in apparatus **60** has a signal input device **62** that can supply a test pattern and a pulsed power supply device **64**. In **FIG. 6**, the components that are given the same reference numerals as in **FIG. 1** have the same functions as in **FIG. 1** and hence will not be described below.

[0054] **FIG. 7** is a time chart that is used in changing the internal state of each semiconductor chip **10** by causing the signal input device **62** to supply each semiconductor chip **10** with a test pattern as an input signal. A circuit of each semiconductor chip **10** can be the same as the circuit described in the embodiment 1 (see **FIG. 3**). For memory devices, the test pattern may be a combination pattern of an address signal and a data signal of a DRAM memory cell circuit. For logic ICs, the test pattern may be a pattern for setting various functions. However, the test pattern of the invention is not limited to such patterns. Where no input signal is supplied, the states of internal circuits are fixed to certain states and hence there may occur a case that only the fixed circuits are charged and discharged. In contrast, stress can be imposed on every circuit by always changing the internal states, whereby the efficiency of a burn-in test can further be increased.

[0055] As described above, the embodiment 5 makes it possible to impose stress to every circuit by changing the internal states of each semiconductor chip **10** by causing the signal input device **62** to supply the semiconductor chip **10** with a test pattern as an input signal before the pulsed power supply device **64** supplies the semiconductor chip **10** with a pulse voltage. Therefore, the efficiency of a burn-in test can further be increased.

[0056] Embodiment 6

[0057] A burn-in test method according to a embodiment 6 of the invention will be described below by using the burn-in apparatus **60** of the embodiment 1 and the time chart of **FIG. 7** showing the waveforms of the power supply voltages and the signal. The semiconductor chip circuit of the embodiment 1 (see **FIG. 3**) is used as an example circuit of each semiconductor chip **10**.

[0058] A test pattern as an input signal is supplied from the signal input device **62** of the burn-in apparatus **60** to each semiconductor chip **10**. For memory devices, the test pattern may be a combination pattern of an address signal and a data signal of a DRAM memory cell circuit. For logic ICs, the test pattern may be a pattern for setting various functions. However, the test pattern of the invention is not limited to such patterns. The internal states of each semiconductor chip **10** supplied with the test pattern are changed in accordance with the test pattern.

[0059] The Vcc voltage is supplied from the pulsed power supply device **64** of the burn-in apparatus **60** to each semiconductor chip **10** whose internal states have been changed, so as to be varied in pulse form in a range from a voltage that is higher than or equal to the threshold voltage Vth to the burn-in voltage Vbi. The GND voltage to the semiconductor chip **10** is fixed at 0 V. In the semiconductor chip circuit **36**, the received pulse Vcc voltage is supplied to the internal circuits **34** via the inverter circuit **33**. The inverter circuit **33** charges the load capacitor **35** of each internal circuit **34** if the input signal is at Vbi and discharges it if the input signal is at 0 V. As a result, a current flows through the wiring that constitutes each internal circuit **34**. Since every internal circuit **34** is supplied with the GND voltage, the supply of the pulse Vcc voltage allows current stress to be imposed on every internal circuit **34**. This enables an efficient burn-in test.

[0060] As described above, the embodiment 6 makes it possible to impose stress to every circuit by changing the internal states of each semiconductor chip **10** by causing the signal input device **62** to supply the semiconductor chip **10** with a test pattern as an input signal before the pulsed power supply device **64** supplies the semiconductor chip **10** with a pulse voltage. Therefore, the efficiency of a burn-in test can further be increased.

[0061] Embodiment 7

[0062] **FIG. 8** is a time chart according to a embodiment 7 of the invention. As shown in **FIG. 8**, a burn-in test method according to the embodiment 7 is different from the burn-in test method of the embodiment 6 in that the Vcc voltage that is supplied from the pulsed power supply device **64** of the burn-in apparatus **60** to each semiconductor chip **10** whose internal states have been changed in accordance with the test pattern is such that a high-voltage period T_H of the pulse Vcc voltage is set longer than a low-voltage period T_L. The voltage stress imposition time can be elongated by increasing the high-voltage period T_H of Vcc input pulses. As a result, the voltage-stress imposition time can be elongated without lowering the efficiency of a current-stress burn-in test, whereby the efficiency of a voltage-stress burn-in test can be increased and the burn-in test time can be shortened.

[0063] As described above, the embodiment 7 makes it possible to elongate the voltage-stress imposition time by modifying the embodiment 6 in such a manner that the high-voltage period T_H of a Vcc input pulse waveform is set longer than the low-voltage period T_L. As a result, the voltage stress imposition time can be elongated without lowering the efficiency of a current-stress burn-in test, whereby the efficiency of a voltage-stress burn-in test can be increased and the burn-in test time can further be shortened.

[0064] Embodiment 8

[0065] **FIG. 9** schematically shows a semiconductor chip circuit according to an embodiment 8 of the invention. As shown in **FIG. 9**, a semiconductor chip circuit **97** has two kinds of pulsed power supply devices **93** and **94**, which are connected to a Vcc1 voltage pad **90** and a Vcc2 voltage pad **91**, respectively. A selection circuit **95** selects a Vcc1 voltage or a Vcc2 voltage in accordance with a control signal that is input via a control signal pad **92**, and supplies a selected voltage to internal circuits **96** as a Vcc voltage. In ordinary use, one of Vcc1 and Vcc2 is supplied to the internal circuits **96**. Because the Vcc voltage is in pulse form, a load capacitor (not shown) that is constituted of a gate capacitance, a wiring capacitance, and a junction capacitance is charged (if the input signal is at Vbi) or discharged (if the input signal is at 0 V) at rises and falls of pulses, whereby a current flows through a wiring that constitute each internal circuit **96**. Since every internal circuit **96** is supplied with the Vcc voltage and the GND voltage, the supply of the pulse Vcc voltage allows current stress to be imposed on every internal circuit **96**. This enables an efficient burn-in test.

[0066] **FIG. 10** shows a burn-in apparatus **100** for performing a burn-in test on the semiconductor chip **10** of **FIG. 9**. In **FIG. 10**, the components that are given the same reference numerals as in **FIG. 1** have the same functions as in **FIG. 1** and hence will not be described below. As shown in **FIG. 10**, the burn-in apparatus **100** has a burn-in control signal generation device (burn-in control signal generator)**102**, a DC power supply device-**1104**, and a DC power supply device-**2106**, and supply a burn-in control signal and power supply voltages to the semiconductor chip **10**. The burn-in control signal generation device **102** is connected to the control signal pad **92** shown in **FIG. 9**, and the DC power supply device-**1104** and the DC power supply device-**2106** are connected to the Vcc1 voltage pad **90** and the Vcc2 voltage pad **91** shown in **FIG. 9**, respectively. This configuration enables an inexpensive burn-in test with a small number of signals even it is a wafer-level test. The number of DC power supply devices shown in **FIG. 10** is not limited to two and may be three or more. The number of power supply voltage pads shown in **FIG. 9** varies depending on the number of DC power supply devices shown in **FIG. 10**.

[0067] As described above, in the embodiment **8**, the semiconductor chip circuit **97** used in a burn-in test method has plural kinds of pulsed power supply devices **93** and **94**, a desired kind of power supply voltage is selected by using a control signal that is input via the control signal pad **92**, and the selected power supply voltage can be supplied to the internal circuits **96** as Vcc. This enables an inexpensive burn-in test with a small number of signals even if it is a wafer-level test.

[0068] Embodiment 9

[0069] A burn-in test method according to a embodiment **9** of the invention will be described below by using the burn-in apparatus **100** and the semiconductor chip circuit **97** of the embodiment 8.

[0070] The DC power supply device-**1104** and the DC power supply device-**2106** of the burn-in apparatus **100** supply DC power supply voltages to the Vcc1 voltage pad **90** and the Vcc2 voltage pad **91**, respectively, of the semiconductor chip circuit **97**. The burn-in control signal generation circuit **102** of the burn-in apparatus **100** supplies a control signal to the selection circuit **95** of the semiconductor chip circuit **97**. The two kinds of DC power supply voltages that are supplied to the Vcc1 voltage pad **90** and the Vcc2 voltage pad **91** are added to pulse power supply voltages that are output from the two kinds of pulsed power supply devices **93** and **94** provided in the semiconductor chip circuit **97**, respectively. One of resulting two kinds of DC-added pulse voltages is selected in accordance with a control signal that is supplied to the selection circuit **95**, and then supplied to the internal circuits **96** as a power supply voltage Vcc. Since every internal circuit **96** is supplied with the Vcc voltage and the GND voltage, the supply of the pulse Vcc voltage allows current stress to be imposed on every internal circuit **96**. This enables an efficient burn-in test.

[0071] The number of DC power supply devices shown in **FIG. 10** is not limited to two and may be three or more. The number of power supply voltage pads shown in **FIG. 9** varies depending on the number of DC power supply devices shown in **FIG. 10**.

[0072] As described above, in the embodiment **9**, the semiconductor chip circuit **97** used in a burn-in test method has plural kinds of pulsed power supply devices **93** and **94**, a desired kind of power supply voltage is selected by using a control signal that is input via the control signal pad **92**, and the selected power supply voltage can be supplied to the internal circuits **96** as Vcc. This enables an inexpensive burn-in test with a small number of signals even if it is a wafer-level test.

[0073] Embodiment 10

[0074] A burn-in test apparatus according to a 10th embodiment is different from the burn-in test apparatus of the first or embodiment 8 in that the Vcc voltage or the Vcc1 voltage and the like that are supplied from the pulsed power supply device **15** of the burn-in apparatus **1** or the pulsed power supply device **93** and the like in the semiconductor chip circuit **97** are a pulse voltage ranging from a voltage that is higher than or equal to the threshold voltage Vth of the switching transistor T1 or the like to a burn-in voltage Vbi (see **FIG. 4**). The application of the Vcc voltage or the like that is higher than or equal to Vth allows the load capacitor **35** or the like to be charged and discharged more easily. As a result, the frequency of the pulse voltage can be increased. Therefore, the current stress can be increased, which leads to increase in burn-in efficiency.

[0075] As described above, the embodiment **10** makes it possible to charge and discharge the load capacitor **35** or the like more easily by varying the Vcc voltage in pulse form in a range from a voltage that is higher than or equal to the threshold voltage Vth of the switching transistors T1 or the like to the burn-in voltage Vbi. As a result, the frequency of the pulse voltage can be increased. Therefore, the current stress can be increased, which leads to increase in burn-in efficiency.

[0076] Embodiment 11

[0077] A burn-in test apparatus according to an 11th embodiment is different from the burn-in test apparatus of the 10th embodiment in that the Vcc voltage or the Vcc1 voltage and the like that are supplied from the pulsed power supply device **15** of the burn-in apparatus **1** or the pulsed

power supply device **93** and the like in the semiconductor chip circuit **97** are such that a high-voltage period T_H of the pulse Vcc voltage or the like is set longer than a low-voltage period T_L. Charge/discharge current stress occurs only in transition periods of rises and falls of Vcc input pulses. Therefore, the voltage stress imposition time can be elongated by increasing the high-voltage period T_H of Vcc input pulses. As a result, the efficiency of a voltage-stress burn-in test can be increased without lowering the efficiency of a current-stress burn-in test, whereby the burn-in test time can be shortened.

[0078] As described above, the 11th embodiment makes it possible to elongate the voltage-stress imposition time by setting the high-voltage period T_H of a Vcc input pulse waveform longer than the low-voltage period T_L. As a result, the efficiency of a voltage-stress burn-in test can be increased without lowering the efficiency of a current-stress burn-in test, whereby the burn-in test time can be shortened.

[0079] As described above, the invention provides a burn-in test method and apparatus and a semiconductor chip to be used in a burn-in test method that allow current stress to be imposed on every circuit node by varying a power supply voltage in pulse form, and thereby enables an efficient burn-in test.

[0080] In the burn-in test method, in the pulse voltage supplying step, the pulse voltage may be varied in a range from a voltage that is higher than or equal to a threshold voltage of the semiconductor chip to the burn-in voltage.

[0081] In the burn-in test method, in the pulse voltage supplying step, the pulse voltage may have a pulse waveform in which a high-voltage period is longer than a low-voltage period.

[0082] Here, the burn-in test method may further comprise, prior to the pulse voltage supplying step, a step of supplying a test pattern for changing an internal state of the semiconductor chip.

[0083] In the burn-in test apparatus, the pulse voltage may be varied in pulse form in a range from a voltage that is higher than or equal to a threshold voltage of the semiconductor chip to the burn-in voltage.

[0084] In the burn-in test apparatus, the pulse voltage may have a pulse waveform in which a high-voltage period is longer than a low-voltage period.

[0085] In the burn-in test apparatus, the burn-in apparatus may supply a test pattern for changing an internal state of the semiconductor chip.

[0086] The present invention has been described in detail with respect to various embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the invention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.

[0087] The entire disclosure of Japanese Patent Application No. 10-346829 filed on Dec. 7, 1998 including specification, claims, drawings and summary are incorporated herein by reference in its entirety.

What is claimed is:

1. A burn-in test method for a semiconductor chip, comprising:

a pulse voltage supplying step of supplying an inverter circuit in a semiconductor chip with a pulse voltage that is output from a pulsed power supply device and varies in a range from 0 V to a burn-in voltage;

a charge/discharge step of charging a load capacitor of an internal circuit of the semiconductor chip by using the pulse voltage if an input signal supplied to the semiconductor chip is at the burn-in voltage, and discharging the load capacitor by using the pulse voltage if the input signal is at 0 V; and

a step of imposing current stress on the internal circuit by using a current generated in said charge/discharge step.

2. The burn-in test method according to claim 1, wherein, in said pulse voltage supplying step, the pulse voltage is varied in a range from a voltage that is higher than or equal to a threshold voltage of the semiconductor chip to the burn-in voltage.

3. The burn-in test method according to claim 2, wherein, in said pulse voltage supplying step, the pulse voltage has a pulse waveform in which a high-voltage period is longer than a low-voltage period.

4. The burn-in test method according to claim 3, further comprising, prior to said pulse voltage supplying step, a step of supplying a test pattern for changing an internal state of the semiconductor chip.

5. The burn-in test method according to claim 1, further comprising, before the pulse voltage supplying step, a step of supplying a test pattern for changing an internal state of the semiconductor chip.

6. The burn-in test method according to claim 2, further comprising, before the pulse voltage supplying step, a step of supplying a test pattern for changing an internal state of the semiconductor chip.

7. A burn-in test apparatus comprising:

a burn-in apparatus having a pulsed power supply device for supplying a pulse voltage that varies in pulse form in a range from 0 V to a burn-in voltage; and

a semiconductor chip that is supplied with the pulse voltage from the pulsed power supply device,

wherein said semiconductor chip has an internal circuit and a load capacitor in said internal circuit, said internal circuit being given current stress in such a manner that a current is caused to flow through said internal circuit by charging said load capacitor when an input signal supplied to said semiconductor chip is at the burn-in voltage, and discharging said load capacitor when the input signal is at 0 V.

8. The burn-in test apparatus according to claim 7, wherein the pulse voltage is varied in pulse form in a range from a voltage that is higher than or equal to a threshold voltage of said semiconductor chip to the burn-in voltage.

9. The burn-in test apparatus according to claim 8, wherein the pulse voltage has a pulse waveform in which a high-voltage period is longer than a low-voltage period.

10. The burn-in test apparatus according to claim 9, wherein said burn-in apparatus supplies a test pattern for changing an internal state of the semiconductor chip.

11. The burn-in test apparatus according to claim 7, wherein said burn-in apparatus supplies a test pattern for changing an internal state of said semiconductor chip.

12. The burn-in test apparatus according to claim 8, wherein said burn-in apparatus supplies a test pattern for changing an internal state of the semiconductor chip.

13. A burn-in test apparatus comprising:

a burn-in apparatus having:

a plurality of DC power supply devices for supplying respective DC voltages; and

a burn-in control signal generation device for generating a burn-in control signal to be used for selecting one of said DC power supply devices; and

a semiconductor chip that is supplied with the DC voltages from said respective DC power supply devices, said semiconductor chip having:

a plurality of pulsed power supply devices for supplying respective pulse voltages that vary in pulse form in a range from 0 V to a burn-in voltage;

an addition section for generating a plurality of pulse supply voltages by adding the DC voltages to the pulse voltages, respectively;

a selection circuit for selecting one of the pulse supply voltages generated by said addition section in accordance with the burn-in control signal; and

an internal circuit including a load capacitor,

wherein the internal circuit being given current stress in such a manner that a current is caused to flow through said internal circuit by charging said load capacitor by using the selected pulse supply voltage when an input signal supplied to said semiconductor chip is at the burn-in voltage, and discharging said load capacitor by using the pulse supply voltage when the input signal is at 0 V.

14. The burn-in test apparatus according to claim 13, wherein the pulse voltage is varied in pulse form in a range from a voltage that is higher than or equal to a threshold voltage of said semiconductor chip to the burn-in voltage.

15. The burn-in test apparatus according to claim 14, wherein the pulse voltage has a pulse waveform in which a high-voltage period is longer than a low-voltage period.

16. The burn-in test apparatus according to claim 15, wherein said burn-in apparatus supplies a test pattern for changing an internal state of said semiconductor chip.

17. The burn-in test apparatus according to claim 13, wherein said burn-in apparatus supplies a test pattern for changing an internal state of said semiconductor chip.

18. The burn-in test apparatus according to claim 14, wherein said burn-in apparatus supplies a test pattern for changing an internal state of said semiconductor chip.

* * * * *

US005353254A

United States Patent [19]

Sakamoto

[11] Patent Number: 5,353,254

[45] Date of Patent: Oct. 4, 1994

[54] **SEMICONDUCTOR MEMORY DEVICE HAVING BURN-IN TEST CIRCUIT**

[75] Inventor: **Harumi Sakamoto**, Ibaraki, Japan

[73] Assignee: **Texas Instruments Incorporated**, Dallas, Tex.

[21] Appl. No.: **887,442**

[22] Filed: **May 21, 1992**

[51] **Int. Cl.**[5] **G11C 29/00**

[52] **U.S. Cl.** **365/201**; 324/765; 371/15.1; 439/54

[58] **Field of Search** ..... 324/158 R; 371/15.1, 371/21.1, 25.1; 439/68, 70, 43, 46, 49, 54; 365/201

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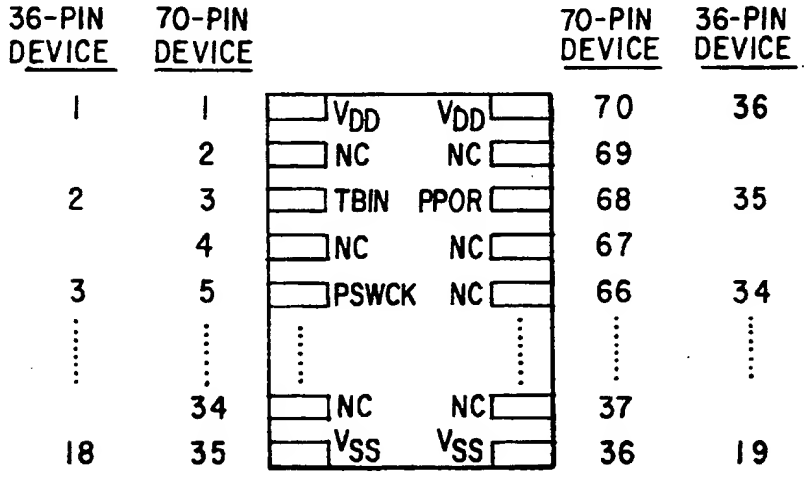
Primary Examiner—Eugene R. LaRoche
Assistant Examiner—F. Niranjan
Attorney, Agent, or Firm—Douglas A. Sorensen; Richard L. Donaldson; William E. Hiller

[57] **ABSTRACT**

The described embodiments of the disclosed invention provide a semiconductor devices, test apparatus for the semiconductor devices and a method for testing the semiconductor devices. The semiconductor devices may have many different types of pin counts and configurations. Each semiconductor device includes standardized test circuitry. The necessary pins to operate the test circuitry are included in a standardized position on the semiconductor devices relative to the positioning of the semiconductor devices in the test apparatus. Thus a single test apparatus may be utilized to test semiconductor devices having a wide range of pin configurations.

18 Claims, 4 Drawing Sheets



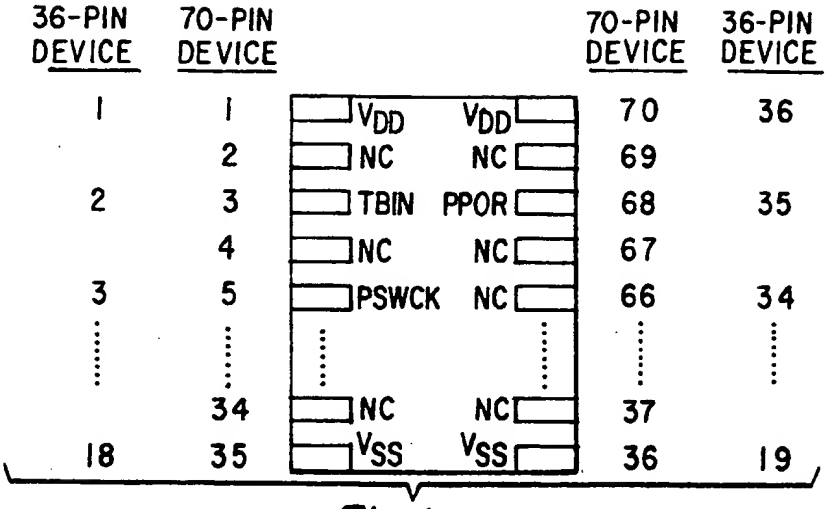


Fig. 1

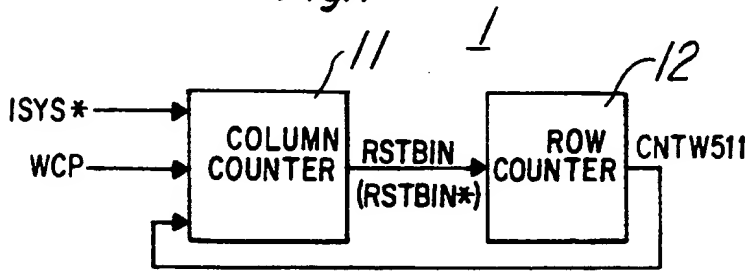


Fig. 2

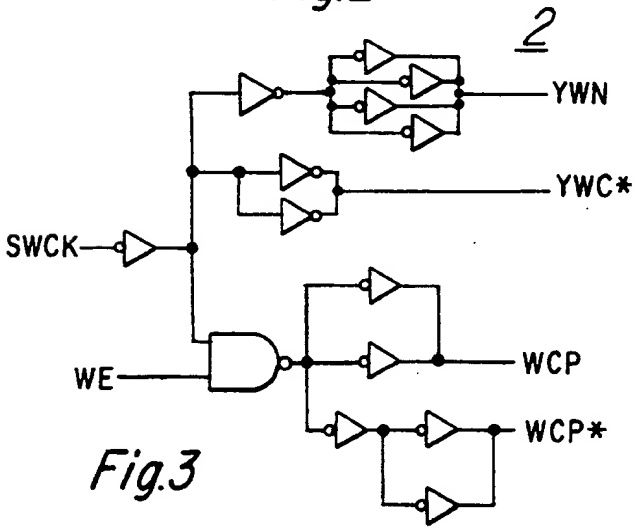


Fig. 3

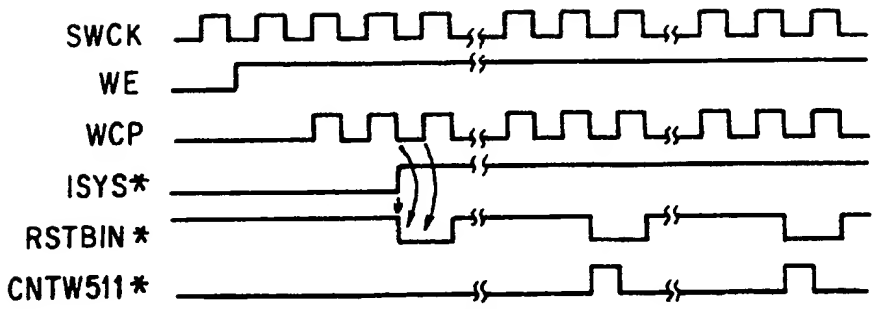


Fig.4

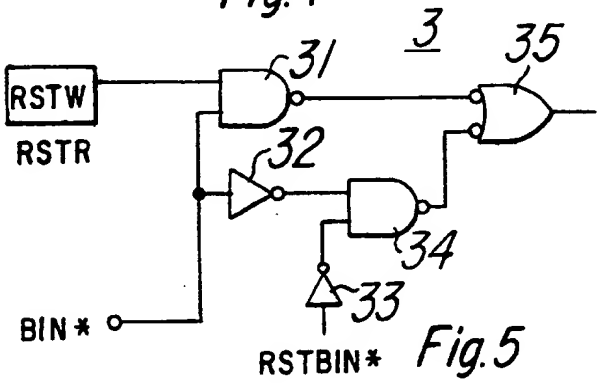


Fig.5

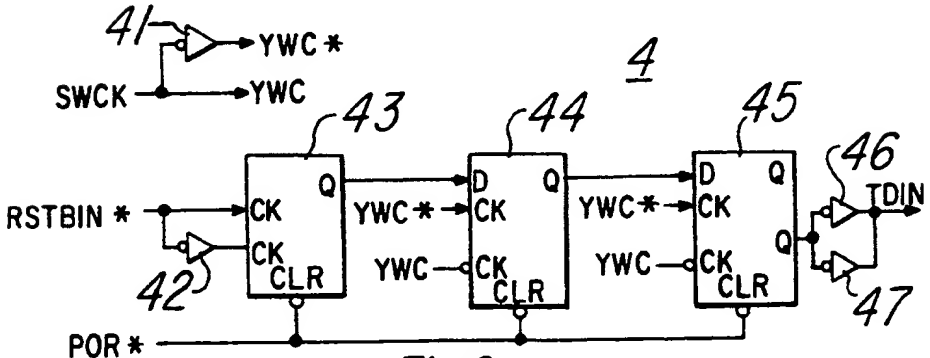


Fig.6

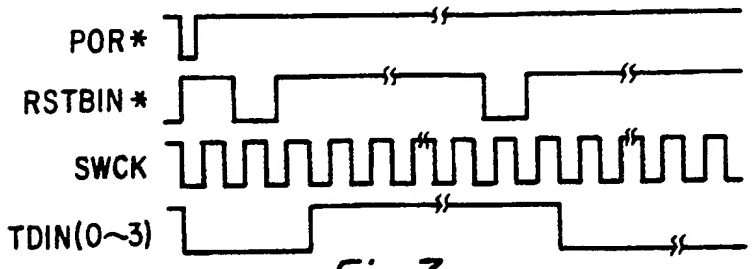


Fig.7

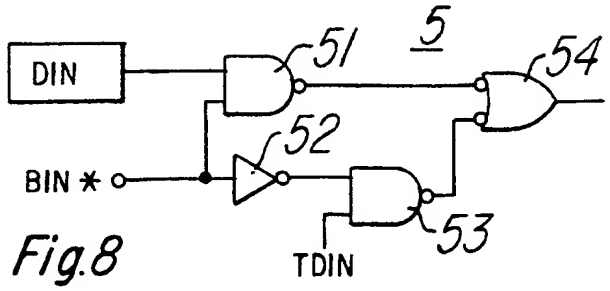


Fig.8

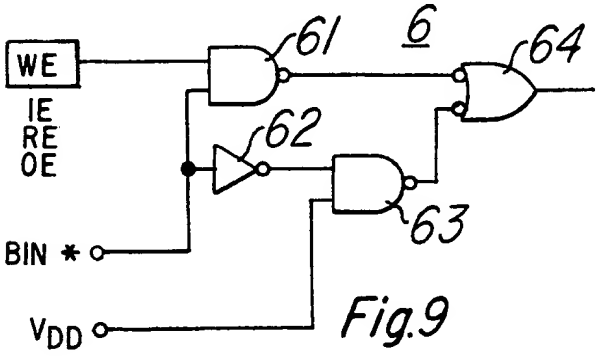


Fig.9

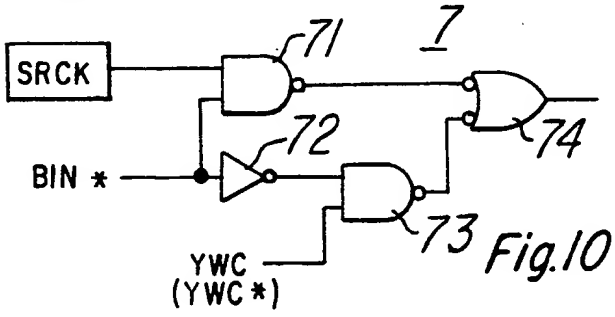


Fig.10

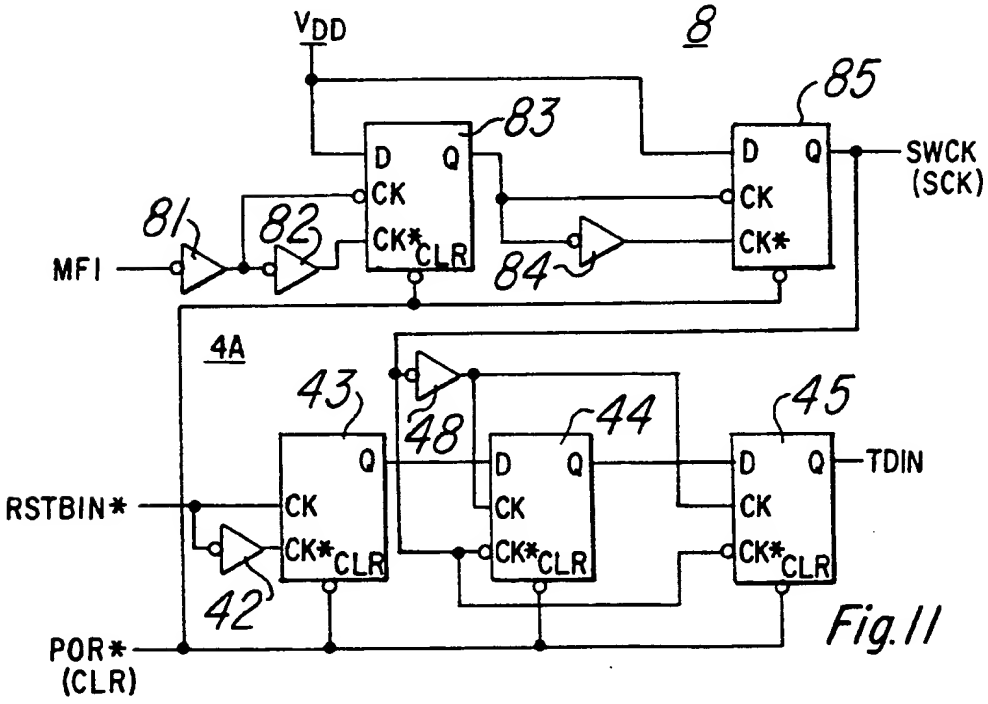


Fig.11

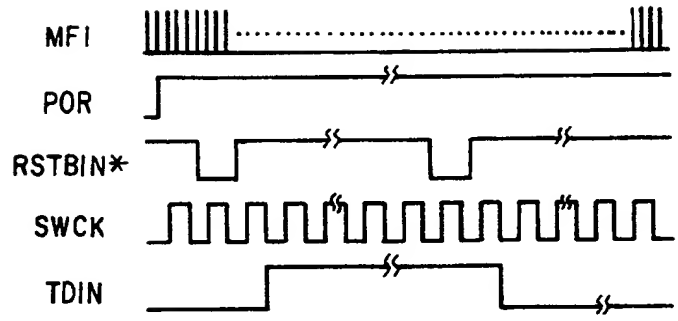

MFI
POR
RSTBIN*
SWCK
TDIN

Fig.12

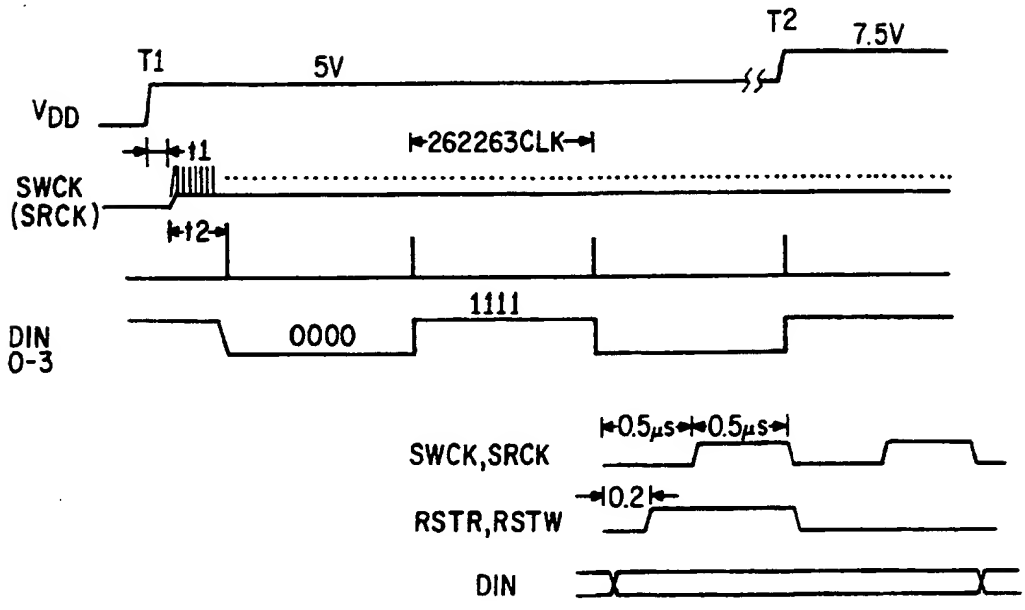

T1
5V
T2
7.5V
VDD
t1
262263CLK
SWCK
(SRCK)
t2
1111
0000
DIN
0-3
0.5μs
0.5μs
SWCK,SRCK
0.2
RSTR,RSTW
DIN

Fig.13

SEMICONDUCTOR MEMORY DEVICE HAVING BURN-IN TEST CIRCUIT

This invention concerns testing of the internal circuit of semiconductor device. More specifically, this invention concerns a test method of semiconductor device which is independent of the pin arrangement of the semiconductor device and can perform the burn-in test effectively.

PRIOR ART

For semiconductor devices, before they are shipped, in order to screen for defective parts, such as inferior gate circuit, capacitor insulating film, etc., the elements are placed in a high temperature of about 125° C., and the power source terminal is connected to a voltage higher than the conventional power source voltage (such as 5 VDC), such as 7–7.5 VDC, for accelerated testing (this test is called 'burn-in test').

In this burn-in test, a plurality of test signals are applied to the various pins of the semiconductor device to be tested via a burn-in test board.

FIG. **13** shows a timing diagram of the burn-in test signals in the field memory.

As shown in this figure, at time point **T1**, a power source voltage V_{DD}, usually 5 VDC, is applied to the field memory. After a prescribed time **t1**, serial write clock SWCK is applied. After a prescribed time **t2**, reset write pulse RSTW is applied. The reset write pulse RSTW is applied periodically for every **262, 263** serial write clock SWCK. Each time when reset write pulse RSTW is applied, the 4-bit test data DIN, **'0000'** and **'1111'**, are applied and are stored in the memory cells of the field memory.

At time point **T2**, the power source voltage V_{DD} rises to 7.5 VDC, and the burn-in test is started. Before time point **T2**, serial write clock SWCK and serial read clock SRCK, reset write pulse RSTW and reset read pulse RSTR are applied, and write and read of the aforementioned data DIN are carried out to/from the aforementioned memory cells. From the results of read, it is tested whether the field memory is damaged in the burn-in test or operates normally.

As the power source voltage V_{DD} rises, the voltages applied to the various elements in the device are also increased, and the elements are in the overload state.

PROBLEMS TO BE SOLVED BY THE INVENTION

In this burn-in test, the content of the test signals depends on the type of the semiconductor device to be tested. In addition, the positions of the test signal application pins also depend on the pin arrangement of the semiconductor device to be tested.

Consequently, for each type of semiconductor device, a specific burn-in test board should be manufactured, and the test time is long. These are problems.

In addition, in order to send the aforementioned test signals from outside the semiconductor device into the semiconductor device with the aforementioned timing, a complicated burn-in test board is needed. This is also a problem.

OBJECT OF THE INVENTION

An object of the present invention is to provide a type of semiconductor device characterized by the following facts: power source terminal, clock application terminal and test mode application terminal are arranged at the common terminal position of the semiconductor devices; the aforementioned semiconductor device has a test signal generating circuit which generates test signals for testing of an internal circuit on the basis of the signals applied from the aforementioned terminals; based on the signals applied from the aforementioned terminals, the aforementioned test signal generating circuit generates a test signals, and based on the test signals, an internal circuit of the aforementioned semiconductor device is tested.

In addition, this invention also provides a test method of an internal circuit of a semiconductor device characterized by the following facts: when the internal circuit of the semiconductor device is tested, power source voltage, clock and test mode signal are input, the test signals needed for testing the aforementioned internal circuit are generated by a test signal generating circuit in the semiconductor device on the basis of the input signals, and are used to carry out a test of the internal circuit of the aforementioned semiconductor device.

For a semiconductor device, a test signal generating circuit needed for testing an internal circuit of the semiconductor device is formed in the semiconductor device in advance. For the semiconductor device, the terminals to which the least signals needed for operating the test signal generating circuit, that is, power source voltage, clock and test mode signal, are applied are defined as the common pins with the semiconductor devices. Consequently, even for different types of semiconductor devices, a test signals can be applied to the same pins.

For the semiconductor device with this configuration, by applying the corresponding signals on the aforementioned pins, test signals are generated by the test signal generating circuit formed in the semiconductor device, and the test signals are applied to the internal circuit of the semiconductor device.

The results after application of the test signals can be found by monitoring the output pins of the semiconductor device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating the pin arrangements of the 70-pin and 36-pin devices in an embodiment of a semiconductor device and its test equipment of this invention.

FIG. **2** is a diagram of a circuit which generates a reset burn-in test signal in the embodiment of this invention.

FIG. **3** is a diagram of a circuit which generates an internal clock in the embodiment of this invention.

FIG. **4** is a timing diagram of generation of the reset burn-in test signal of FIG. **2**.

FIG. **5** is a diagram of a switching circuit which switches the reset burn-in test signal and an externally applied reset write pulse in the embodiment of this invention.

FIG. **6** is a diagram of a circuit which generates a test data in the embodiment of this invention.

FIG. **7** is a timing diagram of the test data.

FIG. **8** is a diagram of a circuit which switches the test data and an external data in the embodiment of this invention.

FIG. **9** is a diagram of a switching circuit which switches an internally generated 'high'-level signal and an external write enable in the embodiment of this invention.

FIG. 10 is a diagram of a circuit which switches the internal clock and an external serial read clock in the embodiment of this invention.

FIG. 11 is a diagram of a circuit which generates a burn-in test signal and a serial write clock in the embodiment of this invention.

FIG. 12 is a timing diagram of the signal generation in the circuit of FIG. 11.

FIG. 13 is a timing diagram of a test signals applied from the exterior in the test of the conventional semiconductor device.

In reference numerals as shown in the drawings:

1, burn-in test signal generating circuit
2, internal clock generating circuit
3, reset burn-in test signal switching circuit
4, 4A, test data signal generating circuit
5, test data signal switching circuit
6, signal switching circuit
7, internal clock signal switching circuit
8, serial write clock generating circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the DIP-format pin arrangements of a field memory in an embodiment of a semiconductor device and its test equipment in this invention. In this embodiment, for both the 70-pin and 36-pin devices, the following pins are shown: power source voltage pins VDD, VSS for application of power source voltages V_{DD}, V_{SS}, pin PSWCK for application of serial write clock SWCK, pin TBIN for application of burn-in test signal BIN, and pin PPOR for application of power on reset signal POR. The pins other than the aforementioned pins are set in the open state (NC).

For the 70-pin and 36-pin devices, the distances between the adjacent pins are different from each other (20 ml pitch and 40 ml pitch, respectively). However, the power source voltage pins VDD, VSS for application of power source voltages V_{DD}, V_{SS}, pin PSWCK for application of serial write clock SWCK, pin TBIN for application of burn-in test signal BIN, and pin PPOR for application of power on reset signal POR are at the same positions. That is, for both the 36-pin and 70-pin devices, it is possible to apply the test signals at the same pin positions. As a result, it is only needed to manufacture one type of burn-in test board, and this single type of burn-in test board can be used for testing a plurality of semiconductor devices.

FIG. 2 shows a configuration diagram of circuit (1) which generates reset burn-in test signal RSTBIN formed in a field memory. This reset burn-in test signal generating circuit (1) consists of column counter (11) and row counter (12). Column counter (11) is input an initial system signal ISYS* (* represents signal inversion) which are generated from the power reset signal POR and write count pulse WCP. As shown in FIG. 3, this write count pulse WCP is generated by internal clock generating circuit (2). Generally speaking, it is signal formed as the AND signal of the serial write clock SWCK and write enable WE.

FIG. 4 shows a timing diagram for generation of reset burn-in test signal RSTBIN. This reset burn-in test signal RSTBIN is then applied to the circuit to be described later.

FIG. 5 shows a configuration of a signal switch circuit (3) which switches said reset burn-in test signal RSTBIN and the reset write signal RSTWor reset read signal RSTR applied via the bonding pad from the exterior in an ordinary operation of the field memory.

This signal switch circuit (3) is formed within the field memory, and consists of inverters (32), (33), NAND gates (31), (34) and NOR gate (35).

In the burn-in test mode, from outside the field memory, and via said burn-in test signal application pin TBIN, a 'low'-level burn-in test signal BIN* is applied, and the aforementioned reset burn-in test signal RSTBIN* is output from NOR gate (35).

In the ordinary operation mode, the burn-in test signal BIN* is on the 'high'-level; signal switching circuit (3) outputs the reset write signal RSTW or reset read signal RSTR applied from the bonding pad in the ordinary operation.

In this way, in the burn-in test mode, reset burn-in test signal RSTBIN* is applied to the internal control circuit of the field memory. In the ordinary operation mode, reset write signal RSTW or reset read signal RSTR is applied.

FIG. 6 shows a circuit diagram of test data generating circuit (4) formed in the field memory. This test data generating circuit (4) consists of inverters (41), (42), (46), (47), T type flipflop (TFF) (43), and delay flipflops (DFF) (44), (45). Inverters (46), (47) function as driver circuits.

FIG. 7 shows a timing diagram of the test data generated by this test data generating circuit (4).

When 'low'-level power-on reset signal POR* is applied from pin PPOR for application of power-on reset signal POR, said FLIP-FLOPS (43)-(45) are reset. Then, when the aforementioned reset burn-in test signal RSTBIN* is applied, corresponding to the serial write clock SWCK applied from pin PSWCK for application of the write clock, the 4-bit internal test data TDIN is output. The test data TDIN are data alternating between '0000' and '1111'.

In the burn-in test mode, the internal data TDIN is stored in the memory cells in the field memory.

Internally generated test data TDIN are applied to signal switching circuit (5) as shown in FIG. 8. Signal switch circuit (5) consists of NAND gates (51), (53), inverter (52), and NOR gate (54).

Just as in the case of signal switch circuit (3) shown in FIG. 5, for this signal switch circuit (5), in the burn-in test mode, when a 'low'-level burn-in test signal BIN* is applied, the aforementioned internal test data TDIN are output; in the ordinary operation mode, when a 'high'-level burn-in test BIN* is applied, data DIN applied from the outside via the bonding pad are output. These data are applied to the memory cells of the field memory. In the burn-in test, the test data TDIN of '0' and '1' are recorded continuously in the memory cells in an alternating way.

FIG. 9 shows signal switching circuit (6) which switches the write enable WE and the internally generated 'high'-level signal. Signal switching circuit (6) consists of NAND gates (61), (63), inverter (62), and NOR gate (64).

In the burn-in test mode, when 'low'-level burn-in test signal BIN* is applied, a 'high'-level signal is always output according to the power source voltage V_{DD} applied to power source pin VDD. In the ordinary operation mode, when a 'high'-level burn-in test signal BIN* is applied, the write enable WE applied from the exterior via the bonding pad is output.

Signal switching circuits of read enable RE, input enable IE, and output enable OE are formed in the field

memory. These signal switching circuits are similar to the signal switching circuit (6) which switches the write enable WE as shown in FIG. 9. Just as with the aforementioned signal switching circuit (6), these signal switching circuits also always output a 'high'-level signal in the burn-in test mode.

FIG. 10 shows switching circuit (7) which switches the internal clock YWC (YWC*) from clock generating circuit (5) shown in FIG. 3 and the serial read clock SRCK applied from the exterior. This signal switching circuit (7) is also formed in the field memory.

Signal switching circuit (7) consists of NAND gates (71), (73), inverter (72) and NOR gate (74). In the burn-in test mode, when 'low'-level burn-in test signal BIN* is applied, said clock YWC (YWC*) is output; in the ordinary operation mode, when 'high'-level burn-in test signal BIN* is applied, the ordinary serial read clock SRCK applied via the bonding pad is output.

By using the aforementioned circuits, on the base of the test signals from outside the field memory, it is possible to carry out accelerated testing of the internal circuits of the field memory, such as the memory cells and the control circuit.

In the burn-in test mode, the power source voltage V_{DD} is usually higher than the ordinary operation mode's power source voltage (such as 5 VDC), and is applied as 7–7.5 VDC, and the accelerated test is carried out at this high power source voltage. The various elements in the device are applied with proportionally higher voltage as related to the power source voltage in the overload test.

According to this invention, in the test, it is only necessary to apply the aforementioned test signals; hence, the burn-in test board with a complicated circuit configuration for generating the test signals as shown in FIG. 13 is not needed in this case. In addition, since the test signals are small in number, the burn-in test board can be further simplified. Furthermore, since only the ON/OFF test signal is applied in the test, the test operation becomes very simple. Also, as described in the above, for a variety of types of semiconductor devices, the pin position of the semiconductor device is the same for all of them for application of the test signals; this makes employment of the test facility very simple since only one type of test board is needed.

As explained above, the test circuit in the field memory has a very simple configuration. Since this circuit is incorporated in the field memory or other semiconductor circuit, there is no problem related to the degree of integration.

In addition, since the test circuit is incorporated in the semiconductor device, it is also possible to carry out the aforementioned test in a simple way even after shipment.

FIGS. 11 and 12 show a second embodiment of this invention.

FIG. 11 shows the serial write clock SWCK generating circuit (8) and test data TDIN generating circuit (4A). FIG. 12 shows the generation timing of serial write clock SWCK and test data TDIN.

Just like circuit (4) shown in FIG. 6, test data TDIN generating circuit (4A) consists of inverter (42), TFF (43), DFF (44), (45) and inverter (48).

Serial write clock SWCK generating circuit (8) consists of inverters (81), (82), TFF (83), inverter (84) and TFF (85).

On the base of power-on reset signal POR* (or clear signal CLR), said circuits (4A) and (8) are reset, and the operation is started. When power source voltage V_{DD} is applied, the oscillator within the field memory is acted and internal clock signal MF1 with a cycle of 780 ns is generated.

In the burn-in test, when testing is to be carried out at a serial write clock SWCK with a cycle of about 800 ns, that is, at a speed higher than the aforementioned cycle of 780 ns, two stages of TFF (83), (85) are used; when 780-ns internal clock MF1 is input, serial write clock SWCK with cycle of 800 ns is generated.

The generation operation of the test data TDIN is identical to the aforementioned operation. DFF (44), (45) are connected as 2 stages, and timing of test data TDIN and that of serial write clock SWCK are matched to each other in the test.

The operation of switching among the following signals is carried out in the same way as above: serial read clock SRCK, reset write pulse RSTW, reset read pulse RSTR, write enable WE, read enable RE, input enable IE, output enable OE, etc.

In this second embodiment, the power source voltage V_{DD} is also higher than the ordinary power source voltage so as to perform the burn-in test. In addition, the frequency of the serial write clock SWCK is also higher than the ordinary frequency to carry out the burn-in test for the field memory. That is, the accelerated test is carried out with a more severe condition.

As described in the above, when this invention is implemented, it is possible to use various modified forms. For example, in said embodiment, the memory is used as an example of the semiconductor device. However, this invention is not limited to the memory, other types of semiconductor devices may also be used to implement this invention.

In said embodiments, the burn-in tests of the semiconductor device were shown as examples. However, this invention is not limited to burn-in testing, it is applicable for the other types of tests.

In addition, in the above, the semiconductor devices described have the DIP type pin arrangement. However, QFP and other pin arrangement may also be used in this invention.

As described in the above, according to this invention, it is possible to carry out testing of the internal circuits of the semiconductor devices in the same way independent of the specific pin arrangement of the semiconductor devices.

According to this invention, the number of types of signals applied to the semiconductor device under test can be reduced, and it is acceptable only to apply on/off logic signals that indicate the switching states; hence, the application of the test signals can be simplified.

What is claimed is:

1. A system for testing a plurality of types of packaged integrated circuits having a plurality of pin configurations comprising:

a socket capable of receiving said plurality of pin configurations;

a reference voltage terminal provided at a first physical pin location of said socket, each of said integrated circuits having a pin for receiving said reference voltage at said first physical pin location;

a supply voltage terminal provided at a second physical pin location of said socket, each of said integrated circuits having a pin for receiving said supply voltage at said second physical pin location; and

at least one control signal terminal provided at a third physical pin location of said socket, each of said integrated circuits including a test circuit for receiving said control signal source and generating control signals appropriate for that integrated circuit, and each integrated circuit having a pin for receiving said control signal at said third physical location.

2. The system of claim 1 wherein said supply voltage provided on said supply voltage terminal is greater than a normal supply level for periods of time determined to coordinate temporally with said control signal.

3. The system of claim 1 wherein said system performs a burn-in test.

4. The system of claim 1 wherein said integrated circuits are memory circuits.

5. The system of claim 1 wherein said integrated circuits are programmable gate arrays.

6. The system of claim 1 further comprising means of elevating the temperature of the integrated circuit being tested.

7. The system of claim 6 wherein said means of elevating the temperature of the integrated circuit is capable of raising the temperature of the integrated circuit to at least 125° C.

8. The system of claim 1 wherein said pin configurations include 70 and 36 pin dual in-line packages.

9. The system of claim 1 wherein said at least one control signal comprises a first, second and third control signals provided at said third, a fourth and a fifth pin position, respectively.

10. A method of testing a plurality of types of packaged integrated circuits having a plurality of pin configurations in a single testing system, comprising the steps of:

providing a socket capable of receiving said plurality of pin configurations;

providing a reference voltage terminal at a first physical pin location of said socket, each of said integrated circuits having a pin for receiving said reference voltage at said first physical pin location;

providing a supply voltage terminal at a second physical pin location of said socket, each of said integrated circuits having a pin for receiving said supply voltage at said second physical pin location; and

providing at least one control signal terminal at a third physical pin location of said socket, each of said integrated circuits including a test circuit for receiving said control signal source and generating control signals appropriate for that integrated circuit, and each integrated circuit having a pin for receiving said control signal at said third physical location.

11. The method of claim 10 wherein said supply voltage provided on said supply voltage terminal is provided at a level greater than a normal supply level for periods of time determined to coordinate temporally with said control signal.

12. The method of claim 10 wherein said method is used to perform a burn-in test.

13. The method of claim 10 wherein said integrated circuits are memory circuits.

14. The method of claim 10 wherein said integrated circuits are programmable gate arrays.

15. The method of claim 10 further comprising the step of elevating the temperature of the integrated circuit being tested.

16. The system of claim 15 wherein said step of elevating the temperature of the integrated circuit raises the temperature of the integrated circuit to at least 125° C.

17. The system of claim 10 wherein said pin configurations include 70 and 36 pin dual in-line packages.

18. The system of claim 10 wherein said at least one control signal comprises a first, second and third control signals provided at said third, a fourth and a fifth pin position, respectively.

* * * * *

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United States Patent [19]

Lee et al.

[11] Patent Number: 5,949,671

[45] Date of Patent: Sep. 7, 1999

[54] **POWER SUPPLY WITH RE-CONFIGURABLE OUTPUTS FOR DIFFERENT OUTPUT VOLTAGES AND METHOD OF OPERATION THEREOF**

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[73] Assignee: **Lucent Technologies Inc.**, Murray Hill, N.J.

[21] Appl. No.: **09/048,246**

[22] Filed: **Mar. 25, 1998**

Related U.S. Application Data

[60] Provisional application No. 60/052,564, Jul. 15, 1997.

[51] **Int. Cl.**[6] **H02M 1/10**

[52] **U.S. Cl.** **363/142**; 363/67; 363/89

[58] **Field of Search** 363/67, 68, 69, 363/89, 142, 143

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Primary Examiner—Shawn Riley

[57] **ABSTRACT**

For use with a DC power supply having first and second output rectifying circuits couplable in alternative configurations to provide dual voltages at an output of the DC power supply, an adaptive voltage controller and a method of adaptively controlling the output voltage. In one embodiment, the adaptive voltage controller includes: (1) a configuration determination circuit, coupled to the output, that generates a configuration signal that is a function of a configuration of the first and second output rectifying circuits, (2) a voltage feedback circuit, coupled to the configuration determination circuit, that develops a voltage feedback signal based on the configuration signal and (3) a voltage control circuit, coupled to the voltage feedback circuit, that receives the voltage feedback signal and controls an output voltage of the DC power supply as a function thereof.

20 Claims, 2 Drawing Sheets

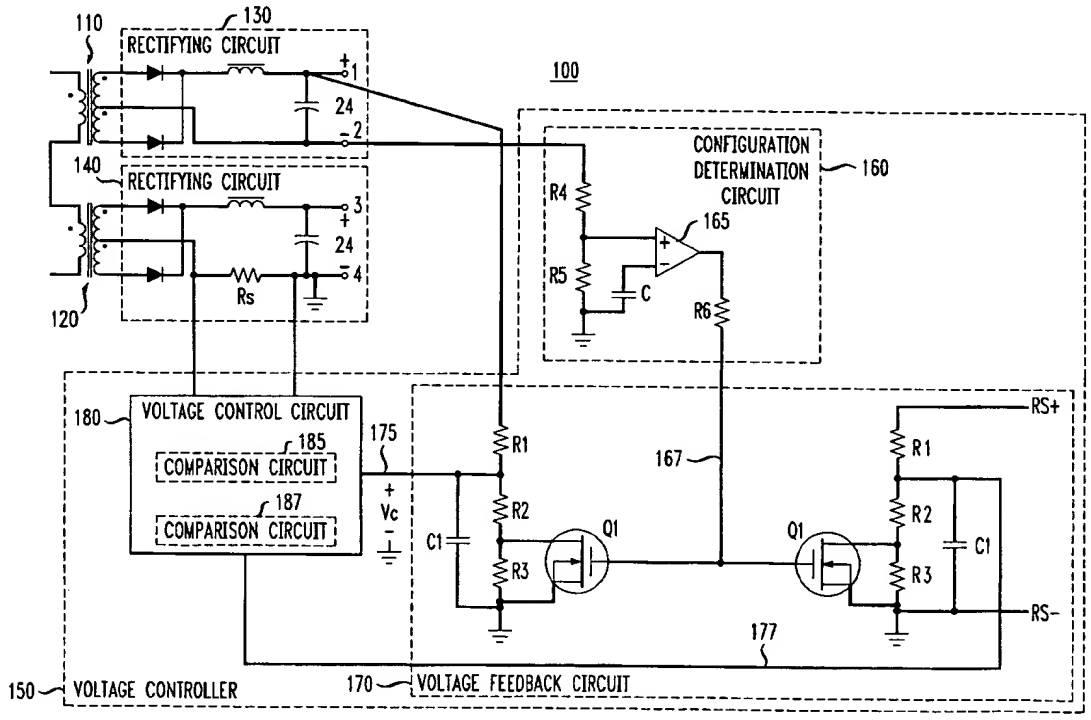


FIG. 1

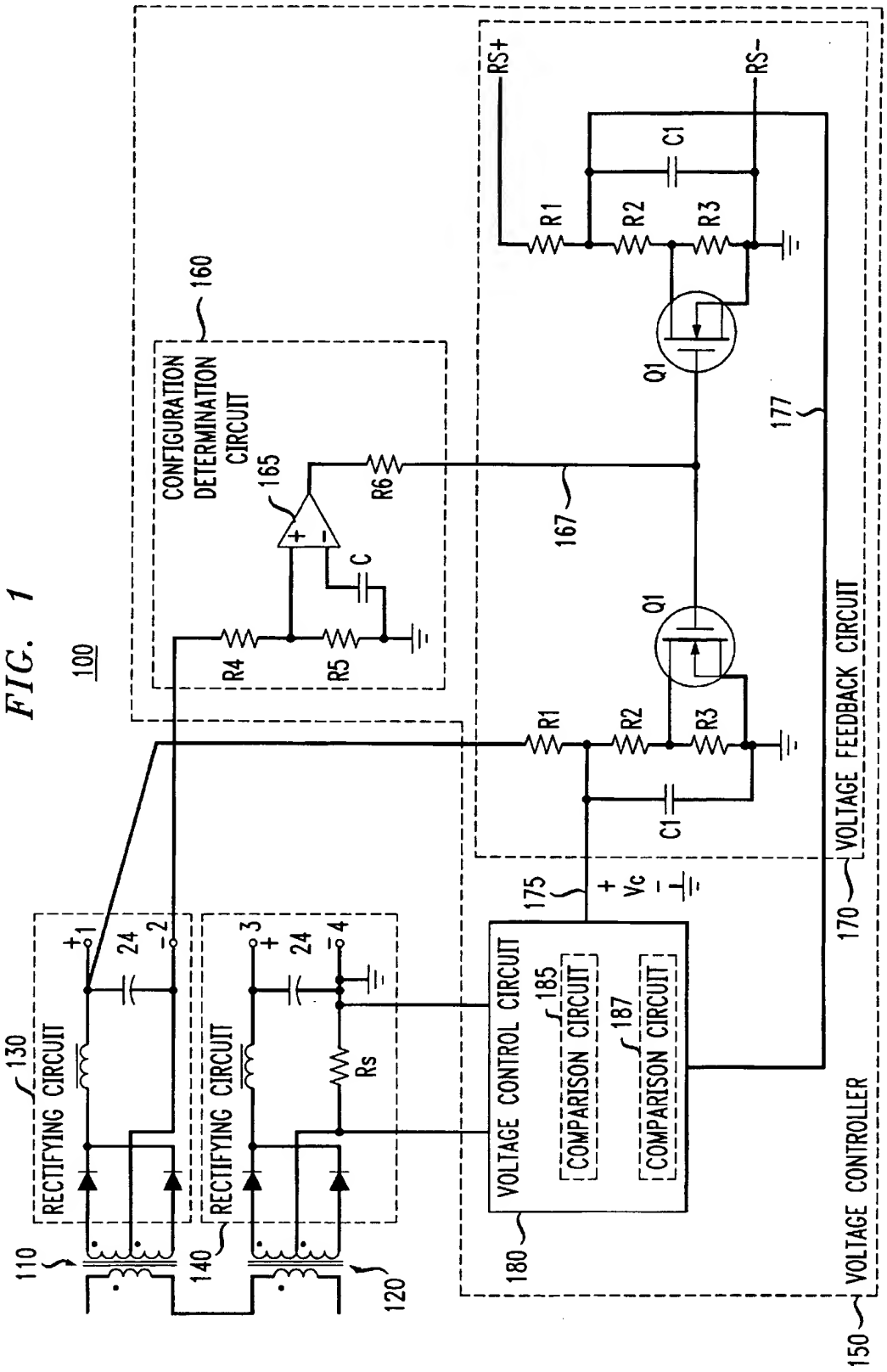
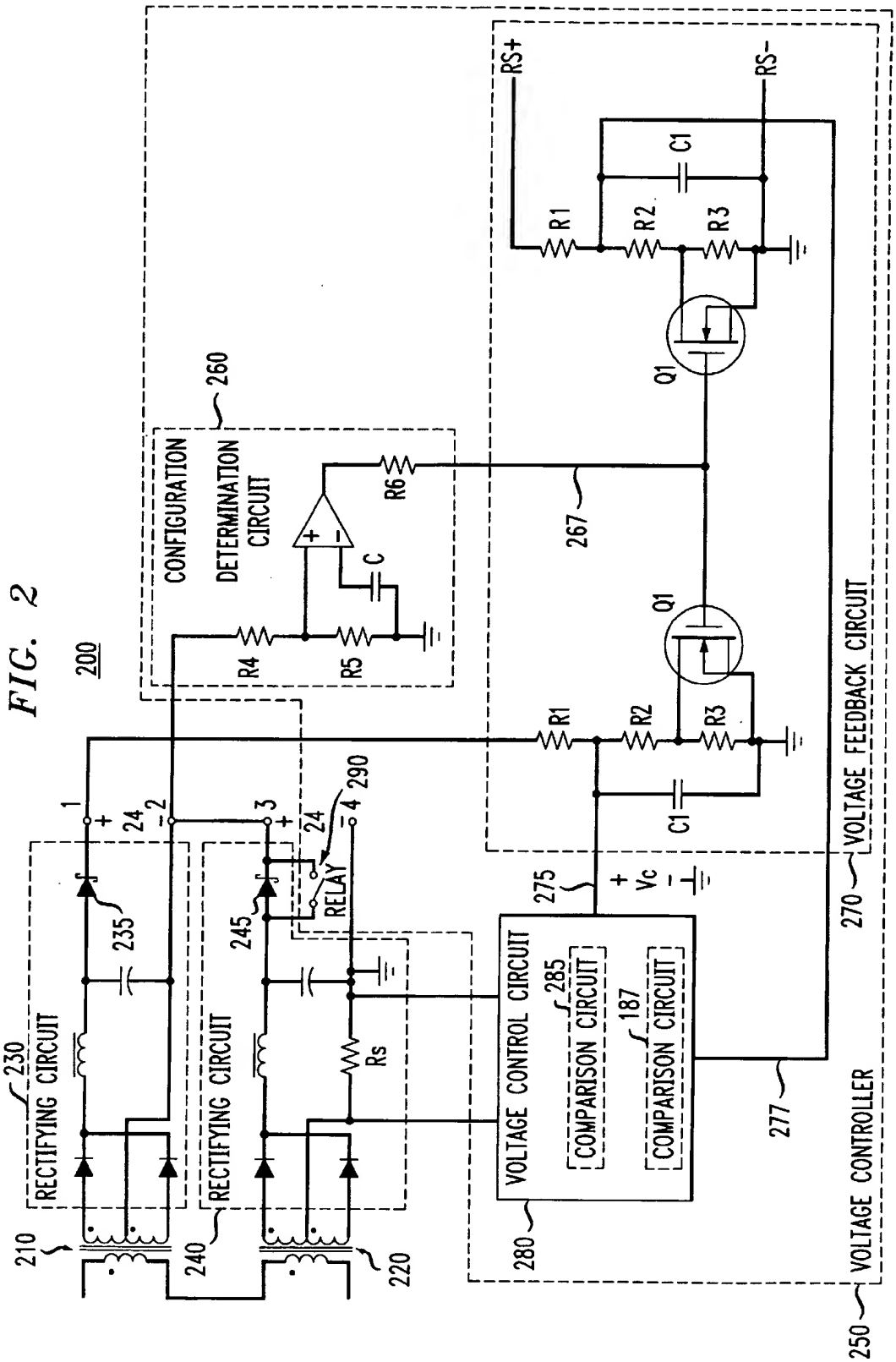

100
CONFIGURATION DETERMINATION CIRCUIT
160
165
R4
R5
R6
C
167
RS+
RS-
R1
R2
R3
C1
Q1
177
VOLTAGE FEEDBACK CIRCUIT
170
175
+ Vc -
VOLTAGE CONTROL CIRCUIT
180
185
COMPARISON CIRCUIT
187
COMPARISON CIRCUIT
VOLTAGE CONTROLLER
150
RECTIFYING CIRCUIT
130
RECTIFYING CIRCUIT
140
Rs
110
120
+1
-2
+3
-4
24
24

FIG. 2


200
RS+
RS-
C1
R1
R2
R3
Q1
260
CONFIGURATION DETERMINATION CIRCUIT
R6
267
C
R4
R5
VOLTAGE FEEDBACK CIRCUIT
270
1
24
2
3
4
290
RELAY
275
Vc
235
245
VOLTAGE CONTROL CIRCUIT
280
285
COMPARISON CIRCUIT
187
COMPARISON CIRCUIT
277
230
RECTIFYING CIRCUIT
240
RECTIFYING CIRCUIT
Rs
210
220
VOLTAGE CONTROLLER
250

POWER SUPPLY WITH RE-CONFIGURABLE OUTPUTS FOR DIFFERENT OUTPUT VOLTAGES AND METHOD OF OPERATION THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This Application claims the benefit of U.S. Provisional application Ser. No. 60/052,564, filed on Jul. 15, 1997, and entitled "Power Supply with Re-configurable Outputs for Different Output Voltages and Method of Operation Thereof," commonly assigned with the present invention and incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to power conversion and, more specifically, to a DC power supply that may be configured to provide alternative output voltages and a method of operating a DC power supply to provide alternative output voltages.

BACKGROUND OF THE INVENTION

The traditional reliability of telecommunications systems that users have come to rely upon is due largely to the systems' operation on highly reliable and redundant power systems. Power systems used in telecommunications applications typically consist of a DC power supply that converts commercial alternating current (AC) power into direct current (DC) power for use by the telecommunications system. To be suitable for use in many different countries, the DC power supply must be compatible with a wide range of voltages and frequencies. Commercial power in Europe, for example, is supplied at 220 VAC, 50 Hz. In the United States, however, a standard voltage is 120 VAC at 60 Hz. In addition, brownouts may significantly reduce line voltages and, conversely, lighter loads, particularly at night, may cause the line voltages to increase. Accordingly, power supplies are typically designed to operate with frequencies between 47 and 65 Hz, and with voltages ranging from 85 VAC to as high as 265 VAC (commonly known as "universal input").

The DC power supply converts this AC voltage to a DC voltage required by telecommunications equipment contained in a particular telecommunications system. The DC power supply generally includes an electromagnetic interference (EMI) filter, a power factor correction circuit and a DC/DC converter. The EMI filter is employed to ensure compliance with EMI standards. The power factor correction circuit converts commercial AC power to a DC voltage, for instance, 400 VDC. The DC/DC converter then scales the high DC voltage down to a lower voltage as required by a board-mounted power supply (BMP) within the telecommunications equipment.

Telecommunications equipment typically operate on one of two voltages: +24 VDC or −48 VDC. Wireless equipment, for instance, often require +24 VDC. Central office equipment, however, typically require −48 VDC. Telecommunications power supplies are, therefore, designed for either +24 VDC or −48 VDC operation.

To maintain high availability of the telecommunications system, the power supplies are used in the power systems in a redundant configuration. Seamless operations of the telecommunications system is assured, even if one DC power supply fails. The failed DC power supply must immediately be replaced, however, to maintain redundancy and avoid future loss of service. Service providers, therefore, must have an inventory of power supplies available for immediate placement in the system. Because of the different voltage requirements of the telecommunications equipment, service providers are currently forced to maintain in reserve both types of power supplies. It would be advantageous, for multiple reasons, to inventory only one type of DC power supply.

Accordingly, what is needed in the art is a DC power supply capable of providing multiple output voltages (e.g., +24 VDC or −48 VDC), as required by the system it powers.

SUMMARY OF THE INVENTION

One way to provide reconfigurable outputs is to have multiple output rectifying circuits. The output rectifying circuits can be configured serially or in parallel to provide the necessary output voltage.

The multiple output rectifying circuits can derive power from a single, common transformer and deliver power to a common load. The output current of each output rectifying circuit, however, may vary due to component tolerances. Though the output power from each rectifying circuit is the same, the output voltages and currents may still vary. Protective functions such as over-voltage and under-voltage shutdown and output current limit must, therefore, be scaled according to the current drawn from each output. If current-sharing can be guaranteed, current sensing may be performed at one output. Under these circumstances, the protective functions need not be individually calibrated for each rectifying circuit.

One way to facilitate current sharing is to match the components of the output rectifying circuits to ensure that current is evenly shared. Unfortunately, component-matching increases the overall time and expense required to manufacture the DC power supply. An alternative way to guarantee current-sharing is to provide separate, series-coupled transformers for each of the output rectifying circuits. By series-coupling the primary windings of the separate transformers, the same current is forced to flow through each transformer and therefore through each corresponding output rectifying circuit.

Once current-sharing is guaranteed (by either of the above-described techniques) the current in one of the output rectifying circuits can be directly controlled, and the other output rectifying circuits are controlled indirectly.

Having ensured that current is shared and correctly controlled, it next becomes necessary to control the output voltage. However, since the DC power supply is capable of selectively providing multiple output voltages, a voltage control technique that adapts to multiple output voltages must be developed.

To address the need for an adaptive voltage control technique, the present invention provides, for use with a DC power supply having first and second output rectifying circuits couplable in alternative configurations to provide dual voltages at an output of the DC power supply, an adaptive voltage controller and a method of adaptively controlling the output voltage. In one embodiment, the adaptive voltage controller includes: (1) a configuration determination circuit, coupled to the output, that generates a configuration signal that is a function of a configuration of the first and second output rectifying circuits, (2) a voltage feedback circuit, coupled to the configuration determination circuit, that develops a voltage feedback signal based on the configuration signal and (3) a voltage control circuit, coupled to the voltage feedback circuit, that receives the

voltage feedback signal and controls an output voltage of the DC power supply as a function thereof.

The present invention therefore introduces the broad concept of adapting the voltage feedback signal in a voltage controller to accommodate different output voltages. This allows a single voltage controller to regulate a reconfigurable DC power supply at its output voltages. While a dual-voltage DC power supply will hereinafter be illustrated and described, the scope of the present invention is not so limited. The present invention generally provides an adaptive voltage control technique that is capable of accommodating two or more alternative voltages at an output of a power supply employing the same.

The foregoing has outlined, rather broadly, features of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing or modifying other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates one embodiment of a DC power supply constructed according to the principles of the present invention; and

FIG. **2** illustrates another embodiment of a DC power supply constructed according to the principles of the present invention.

DETAILED DESCRIPTION

Referring initially to FIG. **1**, illustrated is one embodiment of a DC power supply **100** constructed according to the principles of the present invention. The DC power supply **100** includes a first and second isolation transformer **110, 120** (each having a primary and a secondary winding) coupled to a first and second output rectifying circuit **130, 140**, respectively. In the illustrated embodiment, the first and second transformers **110, 120** have the same turns ratio. The first and second transformers **110, 120** are series-coupled, thereby evenly dividing an output current of the DC power supply **100** between the first and second output rectifying circuits **130, 140**. Those skilled in the art should understand, however, that a single transformer may also be used. The DC power supply **100** further includes an adaptive voltage controller **150** for controlling an output of the DC power supply **100**.

In one embodiment of the present invention, the first and second output rectifying circuits **130, 140** each include a rectifier diode and a filter capacitor. In a preferred embodiment, the first and second output rectifying circuits **130, 140** each include a pair of rectifier diodes, an output inductor, and a filter capacitor. The first and second output rectifying circuits **130, 140** are couplable in alternative parallel and series configurations to provide dual voltages at the output of the DC power supply **100**. In the illustrated embodiment, the dual voltages are +24 VDC and −48 VDC. Of course, the DC power supply **100** may be configured to supply other voltages and more than two voltages. The first and second output rectifying circuits **130, 140** are couplable as follows. In the parallel configuration, a first and second terminal **1, 2** are coupled to a third and fourth terminal **3, 4** respectively. In the series configuration, the second and third terminals **2, 3** are coupled together and the output voltage is provided across the first and fourth terminals **1, 4**.

The voltage controller **150** includes a configuration determination circuit **160**, coupled to the output of the DC power supply **100**, that generates a configuration signal **167** that is a function of a configuration of the first and second output rectifying circuits **130, 140**. In this embodiment of the present invention, the configuration determination circuit **160** consists of a comparator **165** and its associated components (i.e., resistors R4, R5, reference voltage source Vref). The voltage controller **150** further includes a voltage feedback circuit **170**, coupled to the configuration determination circuit **160**, that develops output voltage feedback signals **175, 177** based on the configuration signal **167**. The voltage feedback circuit **170** consists, in this embodiment, of two circuits, each having a resistor ladder formed from a first, second, and third resistor R1, R2, R3, coupled to a resistor bypass switch Q1. Those skilled in the art should realize that the voltage feedback circuit **170** may, in alternative embodiments, consist of one or more circuits, developing one or more voltage feedback signals. The voltage feedback signals **175, 177** of the two circuits represent, respectively, the output voltage sensed at the output of the DC power supply **100** and at a load (not shown). The voltage feedback signals **175, 177** may operate alternatively as required by the DC power supply **100**. The voltage controller **150** still further includes a voltage control circuit **180**, coupled to the voltage feedback circuit **170**. The voltage control circuit **180** consists of, in this embodiment, a set of comparison circuits **185, 187** that receives the voltage feedback signals **175, 177**. Of course, the use of any number of comparison circuits is within the broad scope of the present invention. The voltage control circuit **180** uses the voltage feedback signals **175, 177** to control the output voltage of the DC power supply **100** as a function thereof. Those skilled in the art are familiar with closed loop feedback circuits, and, as a result, an operation of the voltage control circuit **180** will not be described in detail. Additionally, the voltage control circuit **180** may use the voltage feedback signals **175, 177** to initiate under-voltage and overvoltage shutdown.

The present invention therefore introduces the broad concept of adapting the voltage feedback signals **175, 177** in the voltage controller **150** to accommodate different output voltages. This allows the single voltage controller **150** to control a dual-voltage DC power supply at either of its output voltages. While the power supply **100** is a dual-voltage power supply, the scope of the present invention is not so limited.

The operation of conventional DC power supplies should already be familiar to those skilled in the art, and, as a result, the operation thereof will not be described in detail. The voltage controller **150** operates as follows. The configuration determination circuit **160** senses the output voltage of an output terminal of one of the output rectifying circuits **130, 140**. In the illustrated embodiment, the configuration determination circuit **160** senses the output voltage of the second terminal **2**. The output voltage of the second terminal **2** is either +24 VDC or ground, indicating the configuration of the first and second output rectifying circuits **130, 140**. If, for instance, the first and second output rectifying circuits

130, 140 are configured in series to provide –48 VDC, the second and third terminals 2,3 will be coupled together. The output voltage of the second terminal 2 will, therefore, be +24 VDC. If, however, the first and second output rectifying circuits 130, 140 are configure in parallel to provide +24 VDC, the output voltage of the second terminal 2 will be ground (0 VDC). The comparator 165 of the configuration determination circuit 160 thus generates the configuration signal 167 from the output voltage of the second terminal 2.

In the illustrated embodiment of the present invention, the configuration signal 167 assumes a discrete value (e.g., a logic zero or logic one) as a function of the configuration. Alternatively, the configuration signal 167 may be continuously variable or of another function. The present invention is not limited to a particular form of configuration signal 167.

The configuration signal 167 is used by the voltage feedback circuit 170 to generate the voltage feedback signals 175, 177. In the illustrated embodiment, the resistance of the resistor ladder is a function of the configuration signal 167. The configuration signal 167 either enables or disables a resistor bypass switch Q1, altering the overall resistance of the resistor ladder, and thereby producing the voltage feedback signals 175, 177.

The comparison circuits 185, 187 of the voltage control circuit 180 then compare the voltage feedback signals 175, 177 to reference voltages to control the output voltage. Additionally, the comparison circuits 185, 187 may initiate under-voltage and over-voltage shutdown of the power supply 100. Those skilled in the art are familiar with conventional control techniques based on feedback and development of error signals.

Turning now to FIG. 2, illustrated is another embodiment of a DC power supply 200 constructed according to the principles of the present invention. The DC power supply 200 includes a first and second isolation transformer 210, 220 coupled to a first and second output rectifying circuit 230, 240, respectively. In the illustrated embodiment, a first output of the first rectifying circuit 230 is provided across first and second terminals 1, 2. A second output of the second rectifying circuit 240 is provided across third and fourth terminals 3, 4. The DC power supply 200 further includes an adaptive voltage controller 250 for controlling an output of the DC power supply 200.

The first and second output rectifying circuits 230, 240, each include a first and second rectifier diode, an output inductor, and a filter capacitor. Alternatively, the first and second output rectifying circuits 230, 240 may each include a rectifier diode and a filter capacitor. Those skilled in the art should realize that the output inductor and second rectifier diode are not an integral part of the first and second output rectifying circuits 230, 240. The first output rectifying circuit 230 further includes a first output diode 235. The second output rectifying circuit 240 further includes a second output diode 245. The first and second output rectifying circuits 230, 240 are, of course, couplable in alternative parallel and series configurations.

The voltage controller 250 includes a configuration determination circuit 260, coupled to the output of the DC power supply 200, that generates a configuration signal 267 that is a function of a configuration of the first and second output rectifying circuits 230, 240. The voltage controller 250 further includes a voltage feedback circuit 270, coupled to the configuration determination circuit 260, that develops voltage feedback signals 275, 277 based on the configuration signal.

The voltage controller 250 further includes a voltage control circuit 280, coupled to the voltage feedback circuit 270. The voltage control circuit 280 consists of, in this embodiment, a set of comparison circuits 285, 287 that receives the voltage feedback signals 275, 277 and controls the output voltage of the DC power supply 200 as a function thereof. In the illustrated embodiment, the voltage control circuit 280 is a conventional closed loop feedback circuit, familiar to those skilled in the art. The comparison circuits 285, 287 compare the voltage feedback signals 275, 277 to a reference voltage and produce therefrom pulse width modulated drive signals to control switches in a power stage of the DC power supply 200.

The voltage controller 250 still further includes a diode bypass circuit 290, coupled to the second output diode 245, that receives the configuration signal from the configuration determination circuit 260 and bypasses the output diode as a function thereof. In the illustrated embodiment, the diode bypass circuit 290 consists of a relay. Of course, any type of bypass circuit may be used.

The operation of the DC power supply 200 is substantially similar to the operation of the DC power supply 100 of FIG. 1 and will not be described in detail. In the illustrated embodiment, the second and third terminals 2, 3, are coupled together, configuring the first and second output rectifying circuits 230, 240 in series to provide –48 VDC. The configuration determination circuit 260, coupled to the second terminal 2, thus senses +24 VDC. Alternatively, the first and second output rectifying circuits 230, 240 may be configured in parallel to provide +24 VDC. The configuration determination circuit 260 would then sense 0 VDC (ground).

The first and second output diodes 235, 245 protect the first and second output rectifying circuits 230, 240, respectively, when the first and second output rectifying circuits 230, 240 are coupled in a parallel configuration. The second output diode 245 is not required, however, when the first and second output rectifying circuits 230, 240 are series-configured. The diode bypass circuit 290, therefore, bypasses the second output diode 245 as a function of the configuration signal. By bypassing the second output diode 245, any inefficiency associated therewith is eliminated. Of course, the number of diode bypass circuits may vary depending on the number of output rectifying circuits.

In the illustrated embodiment, the first and second output rectifying circuits 230, 240 are in series. The +24 VDC sensed by the configuration determination circuit 260 may thus be used to drive the diode bypass circuit 290 to bypass the second output diode 245. Alternatively, if the first and second output rectifying circuits 230, 240 are in parallel, the 0 VDC (ground) sensed by the configuration determination circuit 260 may be used to turn off the diode bypass circuit 290, thereby leaving the second output diode 245 in the circuit.

Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

What is claimed is:

1. For use with a DC power supply having first and second output rectifying circuits couplable in alternative configurations to provide dual voltages at an output of said DC power supply, an adaptive voltage controller, comprising:

a configuration determination circuit, coupled to said output, that generates a configuration signal that is a function of a configuration of said first and second output rectifying circuits;

a voltage feedback circuit, coupled to said configuration determination circuit, that develops a voltage feedback signal based on said configuration signal; and

a voltage control circuit, coupled to said voltage feedback circuit, that receives said voltage feedback signal and controls an output voltage of said DC power supply as a function thereof.

2. The controller as recited in claim **1** wherein said first and second output rectifying circuits are couplable in alternative parallel and series configurations to provide said dual voltages.

3. The controller as recited in claim **1** wherein said configuration determination circuit senses an output voltage of an output terminal of one of said first and second output rectifying circuits.

4. The controller as recited in claim **1** wherein said configuration signal assumes a discrete value as a function of said configuration.

5. The controller as recited in claim **1** wherein said voltage feedback circuit includes a resistor ladder having a resistance that is a function of said configuration signal.

6. The controller as recited in claim **1** wherein said voltage control circuit comprises a comparison circuit that compares said voltage feedback signal to said output voltage to control said output voltage.

7. The controller as recited in claim **1** wherein one of said first and second output rectifying circuits includes an output diode, said controller further comprising a diode bypass circuit, coupled to said output diode, that receives said configuration signal from said configuration determination circuit and bypasses said output diode as a function thereof.

8. A method of controlling a DC power supply having first and second output rectifying circuits couplable in alternative configurations to provide dual voltages at an output of said DC power supply, comprising the steps of:

generating a configuration signal that is a function of a configuration of said first and second output rectifying circuits;

developing a voltage feedback signal based on said configuration signal; and

controlling an output voltage of said DC power supply as a function thereof.

9. The method as recited in claim **8** wherein said first and second output rectifying circuits are couplable in alternative parallel and series configurations to provide said dual voltages.

10. The method as recited in claim **8** wherein said step of generating comprises the step of sensing an output voltage of an output terminal of one of said first and second output rectifying circuits.

11. The method as recited in claim **8** wherein said configuration signal assumes a discrete value as a function of said configuration.

12. The method as recited in claim **8** wherein said step of developing comprises the step of modifying a resistance of a resistor ladder.

13. The method as recited in claim **8** wherein said step of controlling comprises the step of comparing said voltage feedback signal to said output voltage to control said output voltage.

14. The method as recited in claim **8** wherein one of said first and second output rectifying circuits includes an output diode, said method further comprising the step of bypassing said output diode as a function of said configuration signal.

15. A DC power supply, comprising:

first and second output rectifying circuits, outputs of said first and second output rectifying circuits being alternatively couplable in a parallel configuration to provide power at a lower voltage and couplable in a series configuration to provide power at a higher voltage; and

a voltage controller for controlling said DC power supply at a selected one of said lower and higher voltages, including:

a configuration determination circuit, coupled to said output, that senses an output voltage of an output terminal of one of said first and second output rectifying circuits and generates a configuration signal that is a function of a configuration of said first and second output rectifying circuits,

a voltage feedback circuit, coupled to said configuration determination circuit, that develops a voltage feedback signal based on said configuration signal, and

a voltage control circuit, coupled to said voltage feedback circuit, that receives said voltage feedback signal and controls said output voltage as a function thereof.

16. The power supply as recited in claim **15** further comprising separate first and second transformers coupled to said first and second output rectifying circuits, respectively, said first and second transformers evenly dividing an output current of said DC power supply between said first and second output rectifying circuits.

17. The power supply as recited in claim **15** wherein said configuration signal assumes a discrete value as a function of said configuration.

18. The power supply as recited in claim **15** wherein said voltage feedback circuit includes a resistor ladder having a resistance that is a function of said configuration signal.

19. The power supply as recited in claim **15** wherein said voltage control circuit comprises a comparison circuit that compares said voltage feedback signal to said output voltage to control said output voltage.

20. The power supply as recited in claim **15** wherein one of said first and second output rectifying circuits includes an output diode, said controller further comprising a diode bypass circuit, coupled to said output diode, that receives said configuration signal from said configuration determination circuit and bypasses said output diode as a function thereof.

* * * * *

United States Patent [19]

Lee

[11] **Patent Number: 4,764,652**

[45] **Date of Patent: Aug. 16, 1988**

[54] **POWER CONTROL DEVICE FOR HIGH-FREQUENCY INDUCED HEATING COOKER**

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[73] Assignee: **Gold Star Co., Ltd.**, Seoul, Rep. of Korea

[21] Appl. No.: **41,351**

[22] Filed: **Apr. 22, 1987**

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[4] **H05B 6/06**

[52] **U.S. Cl.** **219/10.77**; 219/10.493; 363/97

[58] **Field of Search** ..... 219/10.77, 10.75, 10.49 R; 363/97, 21, 131

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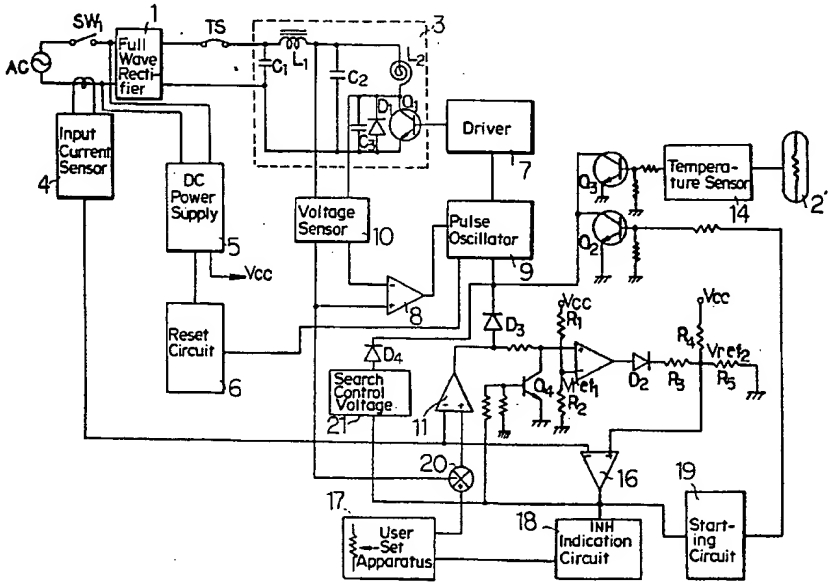
Primary Examiner—Philip H. Leung

Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch

[57] **ABSTRACT**

A power control device for high-frequency induced heating cooker is designed to supply a constant power to the work coil regardless of any change in the input current and voltage. The control device compares the voltage detected at the input current sensor detecting the input current of the full-wave rectifier with the set voltage of the user selector and applies a control voltage to the pulse oscillator and applies the pulse oscillating signal of the pulse oscillator to the driver and makes the switching transistor rapidly turn on and off to generate a high-frequency current through the work coil. It includes a voltage sensor to detect the input and output voltages of the coil, a comparator to compare both detector voltages and to determine the drive starting point of the oscillator, a subtractor to subtract the voltage on the input side of the work coil from the set voltage of the user selector, a comparator to compare the voltage detected at the input current sensor with the normal vessel reference voltage, a transistor to cut off the control voltage applied to the pulse oscillator, a search control voltage part to produce a search control voltage of a constant level and a starting circuit part to generate an oscillation signal of a constant cycle, and a transistor turned on and off by the oscillation signal and supplies the search control voltage to the pulse oscillator in a constant period.

4 Claims, 3 Drawing Sheets



FIG,1

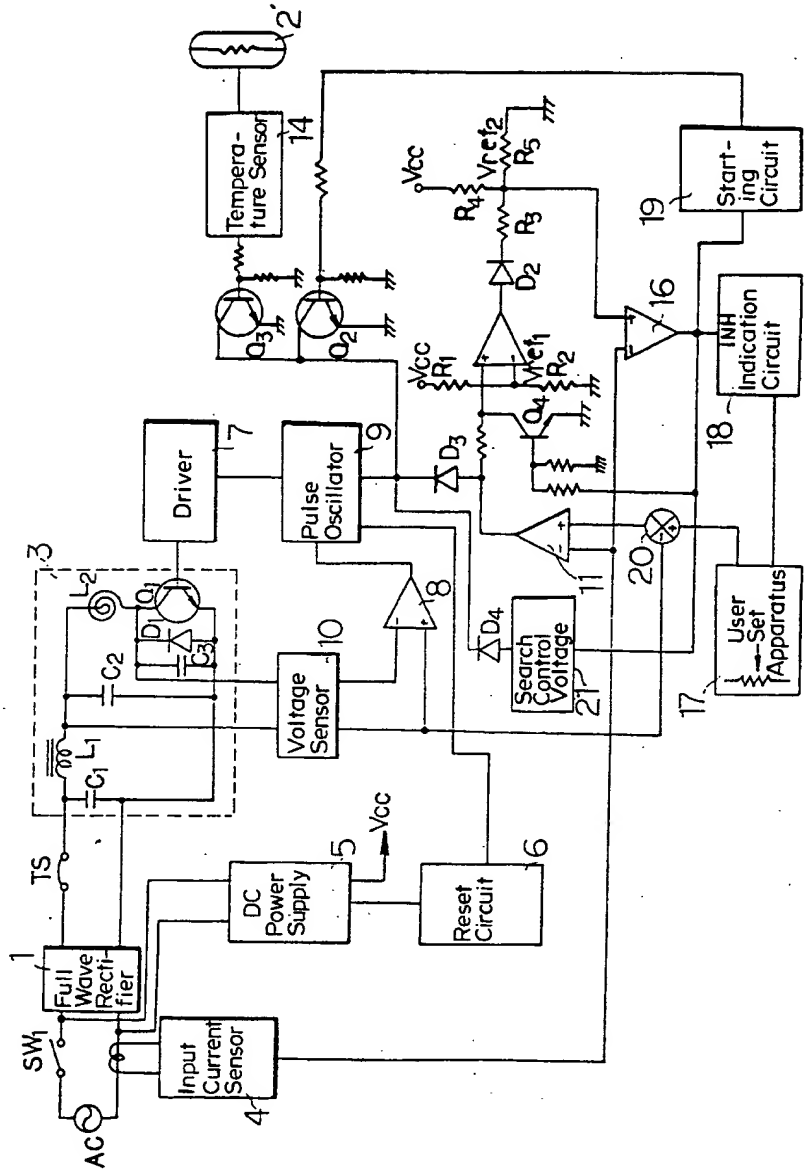
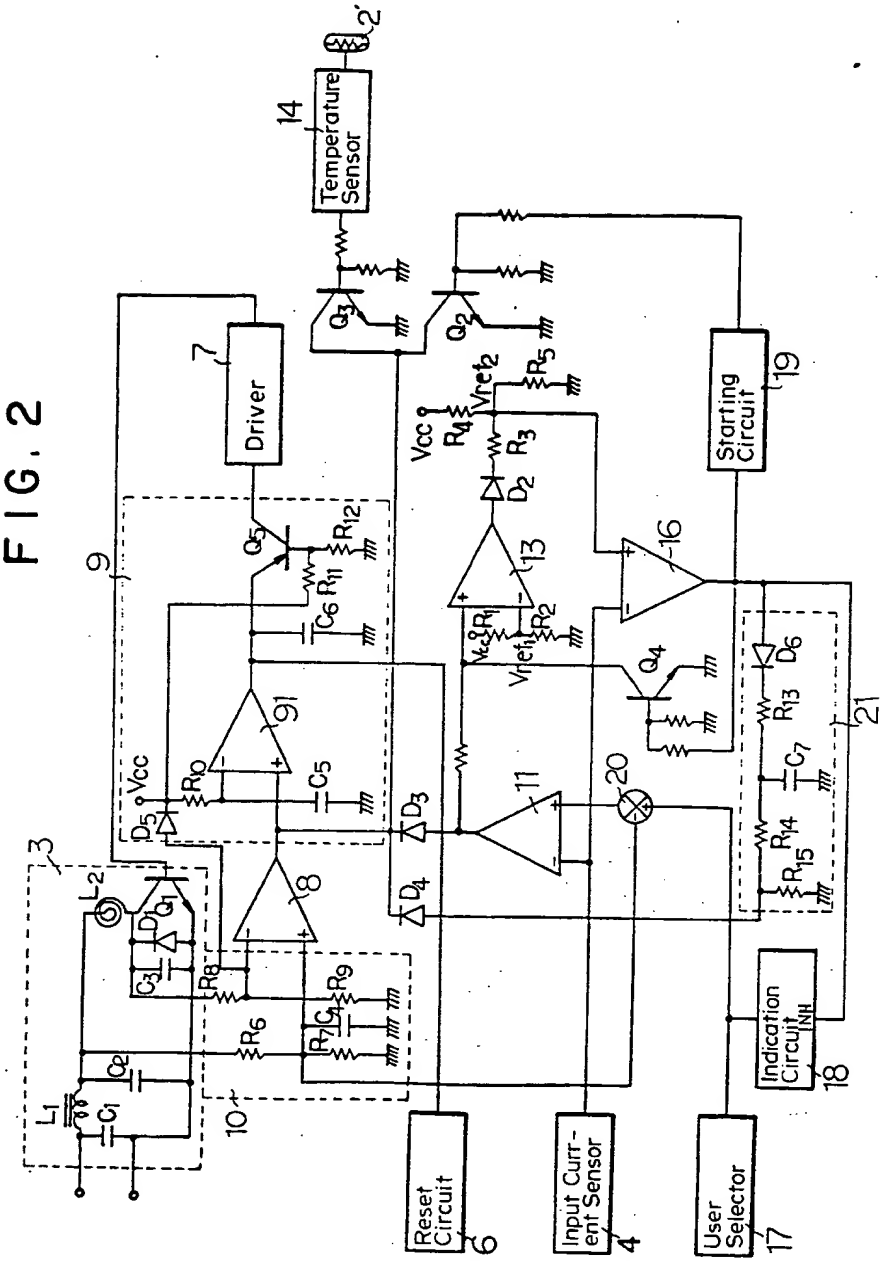
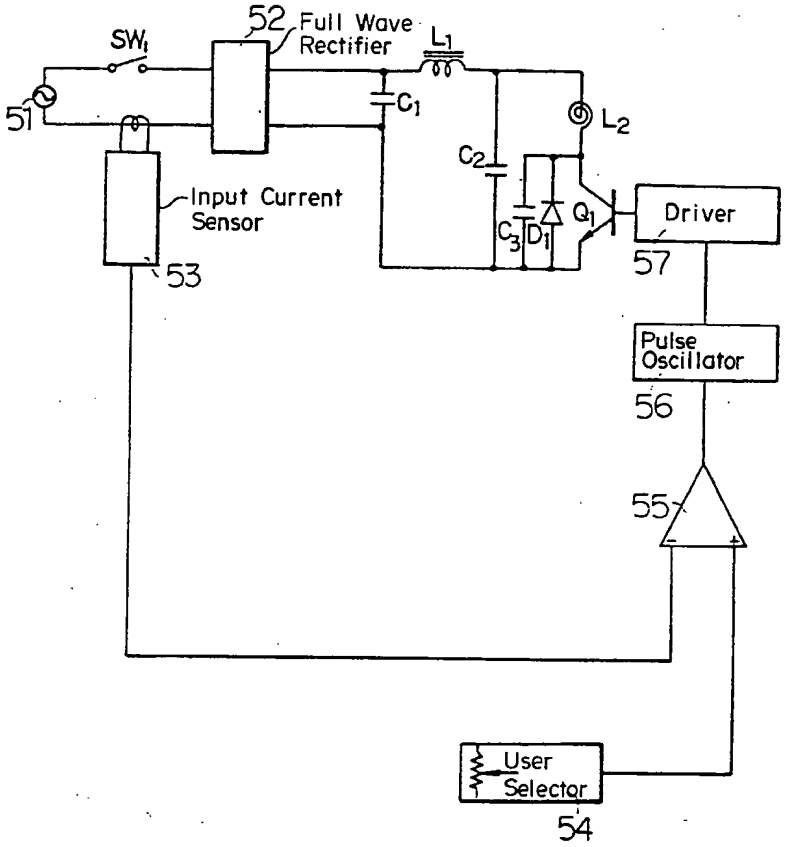

Full Wave Rectifier
DC Power Supply
Reset Circuit
Input Current Sensor
Voltage Sensor
Pulse Oscillator
Driver
Temperature Sensor
Starting Circuit
INH Indication Circuit
User Set Apparatus
Search Control Voltage
AC
SW1
TS
Vcc
Vref1
Vref2

FIG. 2


Temperature Sensor
14
Driver
7
Starting Circuit
19
Indication Circuit
18
Reset Circuit
6
Input Current Sensor
4
User Selector
17
Vcc
Vref2
Vref1
L1
L2
C1
C2
C3
C4
C5
C6
C7
D1
D2
D3
D4
D5
D6
Q1
Q2
Q3
Q4
Q5
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
9
10
11
13
16
18
20
21

PRIOR ART

FIG.3



POWER CONTROL DEVICE FOR HIGH-FREQUENCY INDUCED HEATING COOKER

FIELD OF INVENTION

The invention relates to a power control device for the high-frequency induced heating cooker, particularly a current control device designed to supply a constant electric power to a work coil of the high-frequency induced heating cooker regardless of any change in the input current and voltage.

The high-frequency induced heating cooker is destined to make an eddy current of high-frequency to flow through a vessel of magnetic substance by generating a magnetic force of high-frequency in the work coil and applying it to the vessel of magnetic substance, and to produce thereby the heat by the surface resistance of the vessel so that the materials to be cooked in the vessel are heated.

DESCRIPTION OF THE PRIOR ART

According to the conventional high-frequency induced heating cooker, it is designed to detect the input current in voltage, to compare it with the level set by the user, and to control the drive of a pulse oscillator according to the result of comparison so as to make a constant current flow through the work coil. Consequently, it is impossible to maintain constant the electric power supplied to the work coil. In other words, since the electric power supplied to the work coil is produced by a multiplication of the current and the voltage, any change in the input voltage leads to a change in the supply power so that it is impossible to maintain it constant, and if the input voltage is changed drastically, then the electric power supplied to the work coil is accordingly, changed drastically to reduce the stability of products.

As shown in FIG. 3, which is a circuit diagram of the conventional high-frequency induced heating cooker, the input AC power source **51** is subject to a full-wave rectification in the full-wave rectifier **52**, and after passing through the noise and impulse voltage absorption condenser **C1** and choke coil **L1**, the input is smoothed in the smoothing condenser **C2**, and then it is applied to the resonance circuit of the work coil **L2** and condenser **C3**, while as the switching transistor **Q1** is switched on or off rapidly, the high-frequency current flows. On the other hand, the current put in the full-wave rectifier **52** is detected in voltage at the input current sensor **53**, and the detected voltage is compared at comparator **55** with the set voltage of the user selector **54** to control the drive of pulse oscillator **56**. That is to say, if the detected voltage is lower than the set voltage, then the pulse oscillator **56** is driven to generate the pulse signal of high-frequency which is applied to the base of switching transistor **Q1** through the driver **57** to turn it on or off so that the high-frequency current flows to the work coil **L2**. While if the detected voltage of the input current sensor **53** is higher than the set voltage of the user selector **54**, then the drive of the pulse oscillator **56** is stopped, the switching transistor **Q1** is maintained in the off-state, and thereby a constant current corresponding to the set voltage of the user selector **54** flows to the work coil **L2**.

As described above, the conventional device has a disadvantage in that since it is controlled in such a way that only the input current is detected and a constant current flows thereby to the work coil **L2**, the electric power supplied to the work coil **L2** cannot be changed as the input voltage is changed, which results in the lowering of stability of the products.

SUMMARY OF THE INVENTION

It is the object of the invention to provide a power control device for the high-frequency induced heating cooker designed to supply a constant electric power to the work coil even though the input current and voltage are changed.

It is another object of the invention to provide a power control device for the high-frequency induced heating cooker designed to prevent the current from flowing to the work coil by making the switching transistor off whenever a normal vessel is not placed on the work coil, or the temperature of the surroundings in which the vessel is placed, has risen over a determined temperature.

These objects of the invention are, according to the invention, attained in such a way that in order to make a high-frequency current flow to the work coil by comparing the voltage detected at the input current sensor with the set voltage of the user selector, applying the control voltage to the pulse oscillator, applying the pulse oscillating signal of the pulse oscillator to the driver, and rapidly turning on and off the switching transistor. One detects the voltage put in the input side of the said work coil and subtracts the detected voltage from the set voltage of the said user selector, compares the magnitude of the input and output voltages of the said work coil and determines the drive starting point of the said pulse oscillator. If the voltage detected at the said input current sensor is lower than the reference voltage used in the normal vessel, then one cuts off the control voltage applied to the said pulse oscillator and at the same time supplies and cuts off at a regular period a new search control voltage to the said pulse oscillator, and when the temperature of the surroundings in which the vessel of magnetic substance is placed, has risen over a determined temperature, one cuts of the control voltage supplied to the said pulse oscillator.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings,

FIG. **1** is a circuit diagram of the power control device according to the invention,

FIG. **2** is a detailed circuit diagram of an embodiment shown in FIG. **1**,

FIG. **3** is a circuit diagram of the conventional high-frequency induced heating cooker.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Composition and operational effects of the invention will now be described in more detail with reference to the accompanying drawings.

As shown in FIG. **1**, which is a circuit diagram of the power control device according to the invention, the high-frequency induced heating cooker destined to rectify AC power source at the full-wave rectifier **1** and supply it to the smoothing condenser **C2** and the work coil **L2** through the noise and impulse voltage absorption condenser **C1** and the choke coil **L1** of the inverter part **3**. Also, the cooker will detect in voltage the current put in the said full-wave rectifier **1** at the input current sensor **4**, and compare the detected voltage

with the set voltage of the user set apparatus 17 at the comparator 11 to apply a control voltage to the pulse oscillator 9, and to apply a pulse oscillating signal of the pulse oscillator 9 to the driver 7 and to turn on and off the switching transistor Q1 of the said inverter part 3, so that a high-frequency current flows to the said work coil L2. The circuit comprises a voltage sensor 10 for detecting the voltages on the input side and output side of the said work coil L2, a comparator 8 for determing the drive starting point of the pulse oscillator 9 by comparison of both the detected voltages of the voltage sensor 10, and the subtractor 20 subtracts the voltage on the input side of the work coil L2, which is sensed at the voltage sensor 10, from the set voltage of the user selector 17. Further, a comparator 13 to compare the control voltage put out of the comparator 11 with the vessel removal reference voltage V ref 1 and applies it to the side of normal vessel reference voltage V ref 2, and a comparator 16 compares the detected voltage of the input current sensor 4 and the normal vessel reference voltage V ref 2. Also, a transistor Q4 makes the output control voltage of the comparator 11 flow to the earth by the high-potential output signal of the comparator 16, and a search control voltage part 21 produces the search control voltage and supplies it to the pulse oscillator 9 and a starting circuit part 19 to produce the oscillating signal of constant cycle. Next, a transistor Q2 will cut off and supply the control voltage applied to the pulse oscillator 9 by switching on and off through the oscillating signal of the starting circuit part 19, and a temperature sensing circuit part 14 will sense that the temperature of surroundings in which the vessel is placed, has risen over the determined temperature, and a transistor Q3 will cut off the control voltage switched on by the output signal of the temperature sensing circuit part 14 and apply to the pulse oscillator 9. The undescribed reference number 5 in the description of drawings represents a power supply circuit to put out the constant DC voltage Vcc from AC power source, the reference number 6 represents the reset circuit which applies the driving voltage to the pulse oscillator 9 when the output voltage of the power supply circuit 5 is maintained at a higher level than the constant voltage, the reference number 18 represents the indication circuit which indicates the set voltage state of the user selector 17 when the low potential signal is put out of the comparator 16, and TS represents the thermostat.

As shown in FIG. 2, which is a detailed circuit diagram of an embodiment shown in FIG. 1, the voltage sensor 10 comprises resistors R6–R9 and condenser C4 and detects the voltages on the input side and the output side of the work coil L2 of the inverter part 3, respectively. Both detected voltages are connected so as to be applied to the nonreversible and the reversible input terminals of the comparator 8, and the output side of the comparator 8 is connected to the input side of the pulse oscillator 9 comprising resistors R10–R12, condensers C5, C6, comparator 91 and transistor Q5.

The voltage on the input side of the work coil L2, which is detected at the said voltage sensor 10, is also connected so as to be applied to the minus input terminal of the subtractor 20 and to be subtracted from the set voltage of the user selector 17. The search control voltage part 21 comprises a diode D6, resistors R13–R15 and a condenser C7 so as to put out a search control voltage of a constant level at the time that a high-potential signal is put out of the comparator 16, and the search control voltage is connected so as to be applied to the nonreversible input terminal of the comparator 91 on the input side of the pulse oscillator 9 through the diode D4.

The operational effects of the invention comprised as described above will now be described in more detail.

When the main power supply switch (SW1) is short-circuited, the AC power source is rectified at the full-wave rectifier 1 and then supplied to the work coil L2 of the inverter part 3 through the thermostat TS. The AC power source is supplied to the power supply circuit 5, on the output side of which a constant DC voltage Vcc is put out. When the output voltage of the power supply circuit 5 becomes higher than the set voltage of the reset circuit 6, a constant voltage is put out of the reset circuit 6 and supplied to the output side of comparator 91 of the pulse oscillator 9 and the emitter contact of the transistor Q5.

Consequently, as described later, the pulse oscillator 9 is driven to put out the pulse signal, and this pulse oscillating signal makes the switching transistor Q1 switch on and off rapidly through the drive 7 and the high-frequency current flows thereby to the work coil L2. At this time, the current put in the full-wave rectifier 1 is detected in voltage at the input current sensor 4 and applied to the reversible input terminal of the comparator 11, and the set voltage of the user selector 17 is applied to the nonreversible input terminal of the comparator 11 through subtractor 20 so that the voltage that is proportional to the difference between the voltages put in both input terminals is put out as a control voltage which is applied to the nonreversible input terminal of the comparator 91 on the input side of the pulse oscillator 9 through the diode D3. However, this comparator 91 operates as an open collector. That is, in a case where the control voltage applied to the nonreversible input terminal of the comparator 91 is higher than the voltage applied to its reversible input terminal, its output terminal becomes an open state so that the voltage put out of the reset circuit 6 is charged in the condenser C6 and a high-potential signal is put out to the collector of the transistor Q5. In an opposite case, a low-potential signal is put out to the output terminal of the comparator 91 and the charged voltage of the condenser C6 is discharged so that a low-potential signal is put out to the collector of the transistor Q5.

The time of the high- and low-potential states of the pulse oscillating signal put out of the pulse oscillator 9 is proportional to the level of the control voltage put out of the comparator 11, and the pulse oscillating signal put out of the pulse oscillator 9 controls the on and off of the switching transistor Q1 through the driver 7 so that a constant current flows to the work coil.

On the other hand, since the voltages on the input and output sides of the work coil L2 are detected at the voltage sensor 10 and then applied to the nonreversible and reversible input terminals of the comparator 8, the switching transistor Q1 is off. When when the counter electromotive force is produced from the work coil L2, the voltage applied to the reversible input terminal of the comparator 8 becomes higher than the voltage applied to its nonreversible input terminal so that a low-potential signal is put out to its output side. When the voltage on the input side of the work coil L2 becomes lower than the voltage on its output side, the output terminal of the comparator 8 turns to an open state so that the drive starting point of the pulse oscillator 9 is determined. In other words, when the voltage on the input side of the work coil L2 becomes higher than the

voltage on its output side, and the output terminal of the comparator 8 turns to an open state, the pulse oscillator 9 is driven by the control voltage of the comparator 11 to turn on the switching transistor Q1.

Furthermore, since the voltage on the input side of the work coil L2, which is detected at the voltage sensor 10, is applied to the minus input terminal of the subtractor 20 and subtracted from the set voltage of the user selector 17, the set voltage applied to the nonreversible input terminal of the comparator 11 is decreased in proportion to the increase of the voltage on the input side of the work coil L2. Finally, as the voltage on the input side of the work coil L2 rises, the on-time of the switching transistor Q1 becomes short and its off-time gets long.

Thus, the on and off time of the switching transistor Q1 is controlled by detecting the input current of the full-wave rectifier 1 and the input voltage of the work coil L2, and thereby a constant power is always supplied to the work coil L2.

On the other hand, in a case where a normal vessel of magnetic substance is not placed on the work coil L2, the current flowing through the work coil L2 is reduced and the voltage detected at the input current sensor 4 is lowered, so that the level of the control voltage put out of the comparator 11 relatively rises.

However, at this time, the voltage detected at the input current sensor 4 becomes lower than the normal vessel reference voltage V ref 2 set by the value of resistors R4, R5, the high-potential signal is put out to the output terminal of the comparator 16 to turn on the transistor Q4, and the control voltage of the comparator 11 flows thereby to the earth and the supply to the pulse oscillator is cut off. Since the high-potential signal put out of the comparator 16 is charged to the condenser C7 through the diode D6 and the resistance R13 of the search control voltage part 21, a search control voltage of constant level is put out of the search control voltage part 21, and this search control voltage is supplied to the input side of the pulse oscillator 9 through the diode D4. At this time, the starting circuit part 19 is driven by the high-potential signal put out of the comparator 16 and an oscillation signal of constant cycle is put out. As the transistor Q2 is turned on and off in a constant period by the oscillation signal of the starting circuit part 19, the said search control voltage is supplied to the pulse oscillator 9 in a constant period to drive it in a constant period. Consequently, the switching transistor Q1 is turned on and off in a constant period, and detects whether or not the vessel of magnetic substance is placed on the work coil L2.

In a state that a high-potential signal is put out of the comparator 16, the indication circuit 18 is not driven, and the set voltage level of the user selector 17 is not indicated on the indication circuit.

On the other hand, when the vessel of magnetic substance is removed slowly to a state that the normal vessel of magnegic substance is placed on the work coil L2 and is driven as described above, the current flowing through the work coil L2 is reduced gradually, and the voltage detected at the input current sensor 4 is lowered slowly so that the level of the control voltage put out of the comparator 11 is increased gradually. When the level of this control voltage exceeds the vessel removal reference voltage V ref 1 set by the value of the resistors R1, R2, a high-potential signal is put out to the output terminal of the comparator 13, and this high-potential signal is applied to the nonreversible input terminal of the comparator 16 together with the normal vessel reference voltage V ref 2 through the diode D2 and the resistance R3 so that the voltage applied to the non-reversible input terminal becomes higher than the voltage detected at the input current sensor 4 and a high-potential signal is put out of the comparator 16. As described above, accordingly, the high-potential signal is cut off and the control voltage of the comparator 11 is supplied to the pulse oscillator 9, and at the same time the search control voltage of a constant level is supplied to the pulse oscillator 9 in a constant period to drive the pulse oscillator 9 in a constant period.

When the ambient temperature in which the vessel of magnetic substance is placed, has risen over a determined temperature, it is detected at the temperature sensing part 14 and the transistor Q3 is thereby turned on so that the control voltage is not driven. Since the switching transistor Q1 is kept in an off-state and no current flows to the work coil L2, it is possible to prevent the ambient temperature in which the vessel of magnetic substance is placed, from rising beyond the determined temperature.

Whereas, the thermostat TS, which is mounted on the radiating plate of the switching transistor Q1, is open when the temperature of the radiating plate has risen beyond a determined temperature, to cut off the electric power supplied to the inverter 3.

As described above in detail, it is possible according to the invention to uniformly maintain the output of the work coil regardless of any change in the input voltage by detecting the input current of the full-wave rectifier and the input voltage of the work coil and supplying a constant power corresponding to the level of user set voltage to the work coil, to prevent the current from flowing through the work coil when the ambient temperature in which the vessel of magnetic substance is placed, or the temperature of the radiating plate of the switching transistor has risen beyond a determined temperature, and to always operate the apparatus in a stable area in order to further uniformly control the cooking time by detecting whether or not a normal vessel of magnetic substance is used, and controlling the on and off switching of the transistor.

What is claimed, is:

1. A power control device for a high-frequency induced heating cooker having a work coil driven by inverter means comprising:

rectifier means for rectifying AC power supplied to the inverter means;

input current sensor means for detecting the input current from the AC power supplied to said rectifier means;

first comparator means for comparing the detected input current of the input current sensor means with a manually selectable reference voltage;

pulse oscillator means for generating a rectangular pulse signal;

driver means for applying the rectangular pulse signal to said inverter means to turn said inverter means ON to thereby apply a high frequency current through said work coil;

voltage sensor means for detecting the voltages on both the input and output sides of the work coil;

second comparator means for comparing both detected voltages of the voltage sensor means and determining whether the output of said first comparator means will drive said pulse oscillator means;

means for substracting the voltage detected at the voltage sensor means on the input side of the work coil from the manually selected reference voltage;

third comparator means for comparing the detected voltage of the input current sensor means with a reference voltage which would be generated by the presence of a normal sized cooking vessel on the work coil;

semiconductor switch means for cutting OFF a high potential output signal of the third comparator means;

search control voltage means for generating an oscillating signal during a predetermined period;

starting circuit means for generating an oscillating signal during the predetermined period; and

transistor means turned ON and OFF by the oscillating signal of the starting circuit means for cutting OFF the supply of the search control voltage to said pulse oscillator means at a predetermined time.

2. A power control device for a high-frequency induced heating cooker as claimed in claim 1, further including temperature sensing circuit means for detecting the ambient temperature of the cooking vessel connected to the transistor means for cutting OFF the supply of the search control voltage.

3. A power control device for a high-frequency induced heating cooker as claimed in claim 1, further including fourth comparator means for comparing the output of said first comparator means with a predetermined reference voltage, said fourth comparator means generating a high-potential signal when the removal of a normal cooking vessel is detected by the output of said first comparator means exceeding an additional reference voltage.

4. A power control device for a high-frequency induced heating cooker as claimed in claim 1, further including indication circuit means for indicating a low-potential output signal from the third comparator means.

* * * * *

(1983), or a written justification for contracting on a noncompetitive basis, 41 C.F.R. § 3-3.5301 (1983). Moreover, the numerous form clauses required by federal procurement regulations would have no applicability to this type of collaborative research effort. *See, e.g.*, 41 C.F.R. §§ 1-1.381-7, 1-7 (1983). Confirmatory of this is the fact that HHS itself has used a form similar to Pasteur's September 23, 1983 agreement when sending cell lines to other laboratories.

[1] For the foregoing reasons, we are persuaded that the primary function of the pleaded contracts was facilitation of the transfer of research materials among scientists engaged in a collaborative research effort, not procurement of property or services, and that they, therefore, do not fit within the scope of the Contract Disputes Act. Accordingly, we reverse the judgment of the Claims Court and remand the case for consideration of whether there is a valid and enforceable contract, and, if so, whether it has been breached.

REVERSED AND REMANDED

Court of Appeals, Federal Circuit

Verdegaal Brothers Inc. v. Union Oil Company of California

No. 86-1258

Decided March 12, 1987

PATENTS

1. Patentability/Validity — Anticipation — Prior art (§115.0703)

Federal district court erred in denying patent infringement defendant's motion for judgment n.o.v., in view of evidence demonstrating that claims for making urea-sulfuric acid fertilizer, including claims that reaction be conducted in "heat sink" of recycled fertilizer to prevent high temperature buildup, were anticipated by prior art patent that specifically detailed process for making such urea-sulfuric acid products and that explicitly taught that base or "heel" of recycled fertilizer can be used to make more of product, even if patentee of prior art did not recognize that heel functioned as heat sink, since heat sink property was inherently possessed by heel.

Particular patents — Fertilizers

4,310,343, Verdegaal and Verdegaal, Process for Making Liquid Fertilizer, holding of validity and infringement reversed.

Appeal from District Court for the Eastern District of California, Coyle, J.

Action by Verdegaal Brothers Inc., William Verdegaal, and George Verdegaal, against Union Oil Company of California, and Brea Agricultural Services Inc., for patent infringement. From decision denying defendants' motion for judgment notwithstanding the verdict, defendants appeal. Reversed.

Andrew J. Belansky of Christie, Parker & Hale (David A. Dillard, with him on the brief), all of Pasadena, Calif., for appellants.

John P. Sutton of Limbach, Limbach & Sutton (Michael E. Dergosits, with him on the brief), all of San Francisco, Calif., for appellees.

Before Markey, Chief Judge, and Davis and Nies, Circuit Judges.

Nies, Circuit Judge.

Union Oil Company of California and Brea Agricultural Services, Inc. (collectively Union Oil) appeal from a judgment of the United States District Court for the Eastern District of California, No. CV-F-83-68 REC, entered on a jury verdict which declared U.S. Patent No. 4,310,343 ('343), owned by Verdegaal Brothers, Inc., "valid" and claims 1, 2, and 4 thereof infringed by Union Oil. Union Oil's motion for judgment notwithstanding the verdict (JNOV) was denied. We reverse.

I
BACKGROUND

The General Technology

The patent in suit relates to a process for making certain known urea-sulfuric acid liquid fertilizer products. These products are made by reacting water, urea (a nitrogen-containing chemical), and sulfuric acid (a sulfur-containing chemical) in particular proportions. The nomenclature commonly used by the fertilizer industry refers to these fertilizer products numerically according to the percentages by weight of four fertilizer constituents in the following order: nitrogen, phosphorous, potassium, and sulfur. Thus, for example, a fertilizer containing 28% nitrogen, no phosphorous or potassium, and 9% sulfur is expressed numerically as 28-0-0-9.

The Process of the '343 Patent

The process disclosed in the '343 patent involves the chemical reaction between urea

Appendix D

and sulfuric acid, which is referred to as an exothermic reaction because it gives off heat. To prevent high temperature buildup, the reaction is conducted in the presence of a nonreactive, nutritive heat sink which will absorb the heat of reaction. Specifically, a previously-made batch of liquid fertilizer — known as a "heel" — can serve as the heat sink to which more reactants are added. Claims 1 and 2 are representative:

1. In a process for making a concentrated liquid fertilizer by reacting sulfuric acid and urea, to form an end product, the improvement comprising:

a. providing a non-reactive, nutritive heat sink, capable of dissipating the heat of urea and sulfuric acid, in an amount at least 5% of the end product,

b. adding water to the heat sink in an amount not greater than 15% of the end product,

c. adding urea to the mixture in an amount of at least 50% of the total weight of the end product,

d. adding concentrated sulfuric acid in an amount equal to at least 10% of the total weight of the end product.

2. The process of claim 1 wherein the heat sink is recycled liquid fertilizer.

Procedural History

Verdegaal brought suit against Union Oil in the United States District Court for the Eastern District of California charging that certain processes employed by Union Oil for making liquid fertilizer products infringed all claims of its '343 patent. Union Oil defended on the grounds of noninfringement and patent invalidity under 35 U.S.C. §§102, 103. The action was tried before a jury which returned a verdict consisting of answers to five questions. Pertinent here are its answers that the '343 patent was "valid" over the prior art, and that certain of Union Oil's processes infringed claims 1, 2, and 4 of the patent. None were found to infringe claims 3 or 5. Based on the jury's verdict, the district court entered judgment in favor of Verdegaal.

Having unsuccessfully moved for a directed verdict under Fed. R. Civ. P. 50(a), Union Oil timely filed a motion under Rule 50(b) for JNOV seeking a judgment that the claims of the '343 patent were invalid under sections 102 and 103. The district court denied the motion without opinion.

II
ISSUE PRESENTED

Did the district court err in denying Union Oil's motion for JNOV with respect to the validity of claims 1, 2, and 4 of the '343 patent?

III
Standard of Review

When considering a motion for JNOV a district court must: (1) consider all of the evidence; (2) in a light most favorable to the non-moving party; (3) drawing all reasonable inferences favorable to that party; (4) without determining credibility of the witnesses; and (5) without substituting its choice for that of the jury's in deciding between conflicting elements of the evidence. *Railroad Dynamics, Inc. v. A. Stucki Co.*, 727 F.2d 1506, 1512–13, 220 USPQ 929, 936 (Fed. Cir.), *cert. denied*, 469 U.S. 871 [224 USPQ 520] (1984); *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1546, 220 USPQ 193, 197 (Fed. Cir. 1983). A district court should grant a motion for JNOV only when it is convinced upon the record before the jury that reasonable persons could not have reached a verdict for the nonmoving party. *Railroad Dynamics*, 727 F.2d at 1513, 220 USPQ at 936; *Connell*, 722 F.2d at 1546, 220 USPQ at 197.

To reverse the district court's denial of the motion for JNOV, Union Oil must convince us that either the jury's factual findings are not supported by substantial evidence, or, if they are, that those findings cannot support the legal conclusions which necessarily were drawn by the jury in forming its verdict. *See Perkin-Elmer Corp. v. Computervision Corp.*, 732 F.2d 888, 893, 221 USPQ 669, 673 (Fed. Cir.), *cert. denied*, 469 U.S. 857 [225 USPQ 792] (1984). *Railroad Dynamics*, 727 F.2d at 1512, 220 USPQ at 936. Substantial evidence is more than just a mere scintilla; it is such relevant evidence from the record taken as a whole as a reasonable mind might accept as adequate to support the finding under review. *Consolidated Edison Co. v. NLRB*, 305 U.S. 197, 229 (1938); *Perkin-Elmer*, 732 F.2d at 893, 221 USPQ at 673; *SSIH Equip. S.A. v. U.S. Int'l Trade Comm'n*, 718 F.2d 365, 371 n.10, 218 USPQ 678, 684 n.10 (Fed. Cir. 1983). A trial court's denial of a motion for JNOV must stand unless the evidence is of such quality and weight that reasonable and fair-minded persons in the exercise of impartial judgment could not reasonably return the jury's verdict. *Envirotech Corp. v. Al George, Inc.*, 730 F.2d 753, 758, 221 USPQ 473, 477 (Fed. Cir. 1984).

Our precedent holds that the presumption of validity afforded a U.S. patent by 35

U.S.C. § 282 requires that the party challenging validity prove the facts establishing invalidity by clear and convincing evidence. *American Hoist & Derrick Co. v. Sowa & Sons, Inc.*, 725 F.2d 1350, 1360, 220 USPQ 763, 770 (Fed. Cir.), *cert. denied*, 469 U.S. 821 [224 USPQ 520] (1984). Thus, the precise question to be resolved in this case is whether Union Oil's evidence is so clear and convincing that reasonable jurors could only conclude that the claims in issue were invalid. *See Perkin-Elmer*, 732 F.2d at 893, 221 USPQ at 673; *Railroad Dynamics*, 727 F.2d at 1511, 220 USPQ at 935.

Anticipation

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *See, e.g., Structural Rubber Prods. Co. v. Park Rubber Co.*, 749 F.2d 707, 715, 223 USPQ 1264, 1270 (Fed. Cir. 1984); *Connell*, 722 F.2d at 1548, 220 USPQ at 198; *Kalman v. Kimberly-Clark Corp.*, 713 F.2d 760, 771, 218 USPQ 781, 789 (Fed. Cir. 1983), *cert. denied*, 465 U.S. 1026 [224 USPQ 520] (1984). Union Oil asserts that the subject claims of the '343 patent are anticipated under 35 U.S.C. § 102(e)[1] by the teachings found in the original application for U.S. Patent No. 4,315,783 to Stoller, which the jury was instructed was prior art.

From the jury's verdict of patent validity, we must presume that the jury concluded that Union Oil failed to prove by clear and convincing evidence that claims 1, 2, and 4 were anticipated by the Stoller patent. *See Perkin-Elmer*, 732 F.2d at 893, 221 USPQ at 673; *Railroad Dynamics*, 727 F.2d at 1516, 220 USPQ at 939. Under the instructions of this case, this conclusion could have been reached only if the jury found that the Stoller patent did not disclose each and every element of the claimed inventions. Having reviewed the evidence, we conclude that substantial evidence does not support the jury's verdict, and, therefore, Union Oil's motion for JNOV on the grounds that the claims were anticipated should have been granted.

The Stoller patent discloses processes for making both urea-phosphoric acid and urea-sulfuric acid fertilizers. Example 8 of Stoller specifically details a process for making 30–0–0–10 urea-sulfuric acid products. There is no dispute that Example 8 meets elements b, c, and d of claim 1, specifically the steps of adding water in an amount not greater than 15% of the product, urea in an amount of at least 50% of the product, and concentrated sulfuric acid in an amount of at least 10% of the product. Verdegaal disputes that Stoller teaches element a, the step of claim 1 of "providing a non-reactive, nutritive heat sink." As set forth in claim 2, the heat sink is recycled fertilizer.[2]

The Stoller specification, beginning at column 7, line 30, discloses:

> Once a batch of liquid product has been made, it can be used as a base for further manufacture. This is done by placing the liquid in a stirred vessel of appropriate size, adding urea in sufficient quantity to double the size of the finished batch, adding any water required for the formulation, and slowly adding the sulfuric acid while stirring. Leaving a heel of liquid in the vessel permits further manufacture to be conducted in a stirred fluid mass.

This portion of the Stoller specification explicitly teaches that urea and sulfuric acid can be added to recycled fertilizer, i.e., a heel or base of previously-made product. Dr. Young, Union Oil's expert, so testified. Verdegaal presented no evidence to the contrary.

Verdegaal first argues that Stoller does not anticipate because in Stoller's method sulfuric acid is added *slowly*, whereas the claimed process allows for rapid addition. However, there is no limitation in the subject claims with respect to the rate at which sulfuric acid is added, and, therefore, it is inappropriate for Verdegaal to rely on that distinction. *See SSIH*, 718 F.2d at 378, 218 USPQ at 689. It must be assumed that slow addition would not change the claimed process in any respect including the function of the recycled material as a heat sink.

Verdegaal next argues that the testimony of Union Oil's experts with respect to what

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[1] Section 102(e) provides:

A person shall be entitled to a patent unless—

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent

[2] Claim 4 is written in terms of approximate percentages of all reactants by weight of the end product. No argument is made that the process of claim 4 would result in a fertilizer product any different from that disclosed by Example 8 of Stoller.

Stoller teaches could well have been discounted by the jury for bias. Discarding that testimony does not eliminate the reference itself as evidence or its uncontradicted disclosure that a base of recycled fertilizer in a process may be used to make more of the product.

[1] Verdegaal raises several variations of an argument, all of which focus on the failure of Stoller to explicitly identify the heel in his process as a "heat sink." In essence, Verdegaal maintains that because Stoller did not recognize the "inventive concept" that the heel functioned as a heat sink, Stoller's process cannot anticipate. This argument is wrong as a matter of fact and law. Verdegaal's own expert, Dr. Bahme, admitted that Stoller discussed the problem of high temperature caused by the exothermic reaction, and that the heel could function as a heat sink.[3] In any event, Union Oil's burden of proof was limited to establishing that Stoller disclosed the same process. It did not have the additional burden of proving that Stoller recognized the heat sink capabilities of using a heel. Even assuming Stoller did not recognize that the heel of his process functioned as a heat sink, that property was inherently possessed by the heel in his disclosed process, and, thus, his process anticipates the claimed invention. *See In re Oelrich*, 666 F.2d 578, 581, 212 USPQ 323, 326 (CCPA 1981); *In re Swinehart*, 439 F.2d 210, 212–13, 169 USPQ 226, 229 (CCPA 1971). The pertinent issues are whether Stoller discloses the process of adding urea and sulfuric acid to a previously-made batch of product, and whether that base would in fact act as a heat sink. On the entirety of the record, these issues could only be resolved in the affirmative.

On appeal Verdegaal improperly attempts to attack the status of the Stoller patent as prior art, stating in its brief:

> Verdegaal also introduced evidence at trial that the Stoller patent is not prior art under 35 U.S.C. §§ 102(e)/103. Professor Chisum testified that the Stoller patent, in his opinion, was not prior art. . . . This conclusion finds support in *In re Wertheim*, 646 F.2d 527 [209 USPQ 554] (CCPA 1981), and 1 Chisum on Patents §3.07[3].

Appellee Brief at 27 (record cite omitted). Seldom have we encountered such blatant distortion of the record. A question about the status of the Stoller disclosure as prior art did arise at trial. Union Oil asserted that, even though the Stoller patent issued after the '343 patent, Stoller was prior art under section 102(e) as of its filing date which was well before the filing date of Verdegaal's application. Professor Chisum never testified that the Stoller patent was *not* prior art, but rather, stated that *he did not know* whether it was prior art. An excerpt from the pertinent testimony leaves no doubt on this point:

> Q. (Mr. Sutton): And do you know whether the Stoller patent is prior art to the application of the Verdegaal patent?
>
> A. (Prof. Chisum): I don't know that it is, no.

We find it even more incredible that Verdegaal would attempt to raise an issue with respect to the status of the Stoller patent given that the case was submitted to the jury with the instruction that the original Stoller patent application was prior art.[4] Verdegaal made no objection to that instruction below, and in its appeal briefs, the instruction is cavalierly ignored.

In sum, Verdegaal is precluded from arguing that the Stoller patent should not be considered prior art. *See* Fed. R. Civ. P. 51; *Weinar v. Rollform Inc.*, 744 F.2d 797, 808, 223 USPQ 369, 375 (Fed. Cir. 1984), *cert. denied*, 105 S.Ct. 1844 (1985); *Bio-Rad Laboratories, Inc. v. Nicolet Instrument Corp.*, 739 F.2d 604, 615, 222 USPQ 654, 662 (Fed. Cir.), *cert. denied*, 469 U.S. 1038 (1984).[5]

After considering the record taken as a whole, we are convinced that Union Oil established anticipation of claims 1, 2, and 4 by clear and convincing evidence and that no reasonable juror could find otherwise. Consequently, the jury's verdict on validity is unsupported by substantial evidence and

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[3] There is no dispute that the percentage of heel described in Stoller meets the percentage of heat sink required by the claims.

[4] The jury instruction read:

> Stoller filed two patent applications — an original application on October 30th, 1978, and a second on February 7th, 1980. Under the patent laws, the claims of the 343 patent are invalid if you find that the original application (Exhibit BL) anticipates the process claimed in the 343 patent.

[5] Union Oil also argues that Verdegaal's counsel misled the jury by its closing rebuttal argument:

> [B]ut I think it's important to keep in mind that [Stoller] couldn't have been a prior patent because it issued a month after the Verdegaal patent had issued.

We disapprove of Verdegaal's tactic which would form the basis for a grant of a motion for a new trial but for our conclusion that outright reversal of the ruling on the motion for JNOV is in order.

cannot stand. Thus, the district court's denial of Union Oil's motion for JNOV must be reversed.

Conclusion

Because the issues discussed above are dispositive of this case, we do not find it necessary to reach the other issues raised by Union Oil.[6] In accordance with this opinion, we reverse the portion of the judgment entered on the jury verdict upholding claims 1, 2, and 4 of the '343 patent as valid under section 102(e) and infringed.

REVERSED

District Court, E.D. New York

Propper Manufacturing Co. v. Surgicot Inc.

No. CV 85-1363

Decided November 26, 1986

PATENTS

1. Infringement — Construction of claims — Doctrine of equivalents (§120.0703)

Accused disposable test pack for hospital sterilizer does not infringe claims at issue, even though same result is obtained, since pack does not function in substantially same manner as claimed test pack, nor is accused test pack's outer, non-porous, gas-impermeable, unitary plastic laminated sheet equivalent of claimed porous outer shell sheets.

Particular patents — Sterilizer Tests

4,486,387, Augurt, Disposable Prevacuum Steam Sterilizer Test Device, not infringed.

Action by Propper Manufacturing Co. Inc., against Surgicot Inc., for patent infringement. Judgment for defendant.

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[6] It should not be inferred that all of these issues were properly before us. Union Oil appears to assume that on appeal it may dispute the resolution of any *issue* which is denominated an "issue of law" even though it was not raised in its motion for JNOV. This is incorrect. *See Railroad Dynamics*, 727 F.2d at 1511, 220 USPQ at 934.

Daniel Ebenstein, and Amster, Rothstein & Ebenstein, both of New York, N.Y., for plaintiff.

Gerald J. Flintoft, Michael I. Chakansky, Susan Lee, and Pennie & Edmonds, all of New York, N.Y., for defendant.

Wexler, District Judge.

FINDINGS OF FACT AND CONCLUSIONS OF LAW

1. This is an action by Propper Manufacturing Co., Inc. ("Propper") for infringement of Propper's U.S. Patent No. 4,486,387 issued December 4, 1984 in the name of Thomas A. Augurt, a Propper employee. Propper, a New York Corporation, having an office and principal place of business at 36-04 Skillman Avenue, Long Island City, manufactures and sells medical, surgical and related hospital products. Defendant Surgicot, Inc. ("Surgicot"), is a subsidiary of Squibb, Inc., with a principal place of business at 55 Kennedy Drive, Smithtown, New York. Surgicot manufactures and sells sterilization indicators and sterility assurance materials for use by hospitals.

2. The Surgicot product charged with patent infringement in this case was developed and is manufactured for Surgicot, on a private label basis, by the ATI Division of Warner Lambert Corp. ("ATI"), located in Los Angeles, California.

3. Propper charges Surgicot with infringement of Claims 1, 3 and 5 of the Augurt patent, which relates to a disposable device known as a "test pack" used to test hospital sterilizers to be sure they are functioning correctly. Propper's infringement charge is based upon Surgicot's sale of its "STAR Pack" disposable test pack, made for Surgicot by ATI. Surgicot contends, however, that the Augurt patent is invalid on the grounds that the Augurt invention would have been "obvious" to one of ordinary skill in the art, 35 U.S.C. § 103 (1982), and, in the alternative, that the STAR Pack product does not infringe the Augurt patent. This action was tried by the Court on August 4-7, 1986.

4. While the technical background of the Augurt patent is not significantly in dispute, some technical background is required to understand the issues in this case. The pre-

Court of Appeals, Federal Circuit

Richardson v. Suzuki Motor Co. Ltd.
Nos. 87-1497, -1498, -1502, 88-1083, -1084
Decided February 16, 1989

PATENTS

1. Patentability/Validity — In general (§115.01)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Jury trials (§410.42)

Jury may decide questions of anticipation and obviousness, either as separate special verdicts or en route to verdict on validity, which is also proper question for determination by jury, since there is no reason to distinguish submission of legal questions to jury in patent cases from such jury submissions routinely made in other types of cases.

PATENTS

2. Patentability/Validity — Anticipation — Prior art (§115.0703)

Jury's "advisory" verdict that patentee's rising rate motorcycle suspension was not anticipated, and federal district court's independent holding of validity, are affirmed since reasonable jury could have concluded that claim in issue was not anticipated, in view of totality of evidence including prior art consisting of two prior motorcycle suspension patents and two designs for race car suspensions, and since analysis of district court's decision, based on same prior art, shows no clear error.

3. Patentability/Validity — Obviousness — Evidence of (115.0906)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Jury trials (§410.42)

Federal district court's conclusion, after jury entered verdict of non-obviousness, that obviousness of plaintiff's invention had not been proven and that claim in issue is not invalid, is affirmed despite court's erroneous belief that obviousness issue could only be presented to jury for "advisory" verdict, since review of record shows that there was substantial evidence on which reasonable jurors could conclude that claim had not been proved obvious, and therefore no reversible error occurred.

PATENTS

4. Infringement — Doctrine of equivalents — In general (§120.0701)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Jury trials (§410.42)

Federal district court's judgment of infringement, entered on jury verdict of infringement, is affirmed despite jury's special verdicts that defendant's motorcycle rear suspension linkages are not "equivalent" to patented system, since jury was given incorrect definition of "equivalents" and special verdict interrogatories were prejudicial in that they focused on differences between patented and accused devices without mention of similarities, and since, given correct instructions, reasonable jury could not have found that accused systems, which contain every element of relevant claims but one, are not equivalent to claimed invention.

REMEDIES

5. Monetary — Damages — Patents — Reasonable royalty (§510.0507.03)

Jury's award of 50 cents for each infringing motorcycle sold by defendant as damages for infringement of plaintiff's motorcycle suspension system is vacated, since federal district court improperly instructed jury that infringement was "relatively minor," and since, absent such prejudicial instruction, there was no reasonable basis on which jury could have found that royalty awarded was reasonable.

PATENTS

6. Title — Construction of license agreement (§150.07)

TRADEMARKS AND UNFAIR TRADE PRACTICES

Trade secrets — In general (§400.01)

Federal district court incorrectly instructed jury that only "valid trade secrets" were subject to restraints in contract between plaintiff and defendant since, in view of defendant's agreement not to use or disclose "technical information, know-how, inventions, use data, and design specifications" that it received from plaintiff, jury instructions limited scope of protected information beyond that set forth in contract.

7. Trade secrets — Elements of trade secret (§400.03)

Trade secrets — Disclosure and misappropriation (§400.07)

Federal district court erred by instructing jury that information defendant could have developed on its own was not subject to trade secret protection, that "slavish" copying is necessary for trade secret misappropriation, and that jury could decide whether plaintiff could have both valid patent and legal protection for later-developed information on patented invention, since information capable of independent development or discovery from other sources is not excluded from trade secret protection, misappropriator cannot escape liability by showing modification of, or improvement upon, protected information, and legal status of information and improvements made after patent application has been filed is independent of presence or absence of patent application or ensuing patent.

8. Trade secrets — Elements of trade secret (§400.03)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Jury trials (§410.42)

Federal district court abused its discretion in granting defendant's motion for new trial on issue of whether certain information constituted trade secrets, since court may not vacate jury verdict unless verdict is contrary to clear weight of evidence, is based upon false evidence, or would cause miscarriage of justice, and since there was substantial evidence before jury that information in question was not publicly known, that defendant agreed to receive and preserve it in confidence, and that information fully satisfies statutory and jurisprudential requirements for protectible trade secrets.

REMEDIES

9. Monetary — Damages — In general (§510.0501)

Jury's assessment of $104,000 in damages for defendant's use of certain information obtained from plaintiff is affirmed, since there was substantial evidence presented at trial that would enable jury to determine sum awarded.

10. Non-monetary and injunctive — Equitable relief — In general (§505.0701)

Non-monetary and injunctive — Equitable relief — Permanent injunctions (§505.0709)

Federal district court erred in denying plaintiff's motion for injunction after entering final judgment in plaintiff's favor on issue of patent infringement, since irreparable harm is presumed when clear showing of patent validity and infringement is made and therefore injunction should issue if no sound reason exists for denying it, and patentee should not be denied its right to exclude others from using invention once infringement is established.

PATENTS

11. Patent misuse — Improper procurement and enforcement (§140.03)

TRADEMARKS AND UNFAIR TRADE PRACTICES

Trade secrets — Disclosure and misappropriation (§400.07)

REMEDIES

Monetary — Damages — Unfair trade practices (§510.0508)

Federal district court improperly vacated jury verdicts and ordered new trial on fraud issues after jury found for plaintiff on those issues and entered award of punitive damages, since, although court may have believed that defendant did not commit fraud, record shows that there was evidence on which reasonable jury could support verdicts, and since jury's award of punitive damages, which may be assessed if fraud has been expressly found, was not so disproportionate to damages sustained as to be result of passion or prejudice.

PATENTS

12. Patentability/Validity — Inventorship (§115.13)

Title — Assignments (§150.03)

REMEDIES

Non-monetary and injunctive — Equitable relief — In general (§505.0701)

Federal district court erred in denying motion for assignment of defendant's patent to plaintiff after jury returned special verdict finding that invention asserted in patent was

first disclosed to defendant by plaintiff, since separate special verdict in which jury found that plaintiff was not "real" inventor of invention asserted in disputed patent, and on which court based its denial of motion, reflects jury's understanding of co-inventor status of third party and contributions of others in development of alternate embodiment of invention and therefore does not diminish force of verdict naming plaintiff as person who first disclosed invention to defendant, since neither question of whether plaintiff is sole or joint inventor, which is not before court, nor presence in claims of further modification beyond that disclosed by plaintiff to defendant, negates imposition of equitable remedy of assignment of patent, and since, based on jury verdict, plaintiff is entitled to ownership of patent as against defendant.

13. Monetary — Damages — Prejudgment interest (§510.0511)

Federal district court erred in denying plaintiff's request for prejudgment interest on damage awards for patent infringement and misappropriation of trade secrets, since allowance of such interest is required if, as in instant case, there is no showing of exceptional circumstances or reason why damages for trade secret misappropriation should be treated differently from those for patent infringement.

JUDICIAL PRACTICE AND PROCEDURE

14. Procedure — Jury trials (§410.42)

REMEDIES

Monetary — Damages — Patents — Increased damages (§510.0507.07)

Federal district court erred in refusing to submit question of willful patent infringement to jury, since evidence adduced at trial concerning fraud, misappropriation of trade secrets, absence of any opinion by U.S. counsel concerning validity of plaintiff's patent at commencement of defendant's infringing activity, and defendant's bad faith, when viewed in light most favorable to plaintiff, does not permit finding of no willful infringement as only reasonable conclusion.

15. Monetary — Attorney's fees; costs — Patents (§510.0905)

Monetary — Attorney's fees; costs — Unfair trade practices (§510.0907)

Federal district court's award of only one-third of costs to plaintiff who prevailed on major substantive issues in suit exceeded court's authority, since plaintiff is entitled to statutory costs incurred before trial court.

Particular patents — General and mechanical — Vehicle suspension systems

3,907,332, Richardson, suspension system for two-wheeled vehicles, valid and infringed.

4,457,393, Tamaki and Suzuki, suspension device for motorcycles, assignment to Donald G. Richardson ordered.

Appeal from the U.S. District Court for the Central District of California, Gray, J.

Action by Donald G. Richardson against Suzuki Motor Co. Ltd., U.S. Suzuki Motor Corp., Kawasaki Heavy Industries Ltd., Kawasaki Motors Corp., Yamaha Motor Co. Ltd., Yamaha Motor Corp. U.S.A., Kayaba Industry Co. Ltd. and Kayaba Industry Co., for patent infringement, breach of contract, fraud and misappropriation of trade secrets. From judgment holding plaintiff's patent not invalid and infringed, awarding damages for infringement and use of plaintiff's information by defendant, and from grant of defendant's motion for new trial on issues of trade secrets, fraud, and damages awarded for fraud, Richardson and Suzuki defendants cross-appeal. Affirmed in part, reversed in part, vacated in part, and remanded.

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Before Skelton, senior circuit judge, and Smith and Newman, circuit judges.

Newman, J.

This appeal and cross-appeal are from the judgment of the United States District Court for the Central District of California, and involve issues of patent validity, infringement, breach of contract, fraud, misappropriation of trade secrets, and several related

issues.[1] We affirm in part, reverse in part, vacate in part, and remand.

The Invention

The invention that led to this litigation is a motorcycle rear-wheel suspension system that smooths the ride over rough terrain, of interest particularly in off-road motorcycle riding. The roughness of the ride is due to bumps and dips in the terrain, transmitted from the wheels to the frame. An optimum rear-wheel suspension will maintain tire contact with the ground despite deflection by irregularities, will avoid "bottoming out" (an unsafe rising of the suspension), yet will achieve a smooth ride without reduction in safety. In 1974 even the best available suspensions did not maintain adequate tire contact with the ground in conjunction with attempts to eliminate bottoming out.

In mid-1974 Donald G. Richardson, a young mechanic in California, devised a solution to the problem, a modified suspension system that he installed in his own motocross motorcycle. Richardson replaced the conventional two-spring shock absorber suspension system with a system consisting of a single shock absorber plus a linkage consisting of a bell crank and connecting rod. This linkage generated a "rising rate"[2] — a characteristic critical to the issue — and produced a far superior ride, even as it eliminated the dangerous bottoming out. Richardson testified about his first ride, at a hilly construction site near his house, as "utopia. I mean it was incredible"; over hard bumps it was "uncanny because it was so smooth"; "[t]he rear end didn't kick up. It just didn't bottom out and stayed down"; an "unbelievable feeling".

On November 25, 1974 Richardson filed a United States patent application on his invention, and on September 23, 1975 the application issued as United States Patent No. 3,907,322 (hereinafter the '332 or Richardson patent). Patent claim 9, which incorporates claim 1, is the only claim in suit. Claims 1 and 9 follow:

1. A suspension for two wheeled vehicles comprising:

a frame for the vehicle comprising a generally closed shape including upper and lower portions

and a swing arm pivotally connected to the lower portion of said frame;

said swing arm comprising a pair of arms rotatably supporting a wheel about a horizontal axis generally at the end of said swing arm;

the pivotal mounting of said arm to said frame being about a generally horizontal axis whereby said wheel is both rotatable about its own horizontal axis and deflectable in a generally vertical direction about the axis of said swing arm;

spring means having a first end pivotally secured to said frame;

a link member including an intermediate point pivotally mounted on said frame about an axis, parallel to the axis of said swing arm at a point spaced therefrom;

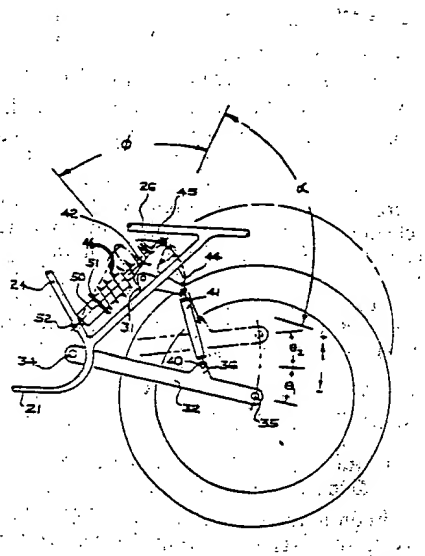
pivotal connection means between said link member and the second end of said spring;

a bar pivotally connected at one end to said swing arm and at the opposite end to said link member at a position spaced from said spring connection;

said spring, bar, swing arm and link connected whereby deflection of said swing arm displaces said bar and rotates said link member to compress said spring.

9. The combination in accordance with claim 1 wherein said assembly provides a rising spring rate as a function of deflection of said swing arm.

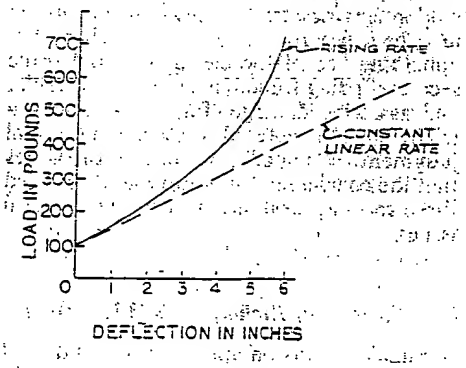
Figure 2 of the '332 patent specification is illustrative:



[1] *Richardson v. Suzuki Motors Co. and Suzuki U.S. Motors Corp.*, Nos. CV 80-2589-WPG and CV 82-3826-WPG (C.D. Cal. June 29, 1987 and July 13, 1987).

[2] "Rising rate" was described by witnesses as follows: "as the suspension travels upward, the resistance to upward travel will increase"; and it "gets stiffer as the wheel moves up toward the vehicle or moves upward in the frame."

As the rear wheel is deflected upward by bumps in the terrain, the swing arm (32) that is pivotally connected at (34) to the motorcycle frame (21) rotates upward, pushing the compression rod (41) into the bell crank (42) that is pivotally secured (31) at its intermediate point to the motorcycle frame. The bell crank rotates on its pivot (31) and compresses, downward against the frame, a spring (46) that is pivotally connected at one end (45) to the bell crank, and at its other end (52) to the motorcycle frame. The interaction of these interconnected parts increases the force on the spring, increasing the rate of resistance to deflection of the wheel with increased movement of the wheel. This varying resistance is the "rising spring rate" of claim 9, and is illustrated in Figure 5 of the '332 patent:



The Contact with Suzuki

In October 1978 Richardson entered into a one year Option and License Agreement with the Suzuki Motor Co., Ltd. of Japan ("Suzuki").

The Agreement gave Suzuki the exclusive right to test and evaluate Richardson's suspension, and the exclusive option to acquire an exclusive license to the '332 patent and Richardson's "proprietary technical information, know-how, inventions, and use data", collectively defined in the Agreement as the "Licensed Rights."

The Agreement required Richardson to disclose to Suzuki all technical information, know-how, inventions, use data and design specifications for his suspension, that he possessed or that he acquired during the option period. Suzuki agreed to preserve all such information in confidence, and not to use any of it "for any purpose other than to evaluate for commercial feasibility of manufacture and marketing during the Option Period." Suzuki agreed that this obligation of confidence continued if Suzuki did not exercise the option. Excepted from the confidentiality obligation was all information previously known to Suzuki or at any time generally known to the public.

The agreement required Richardson to make prototypes of his suspension system for Suzuki's evaluation. Richardson installed his suspension in Suzuki's sample 1978 and 1979 model production motorcycles, and disclosed to Suzuki the technical information and know-how that he possessed, including improvements and other information that he developed during this period. He met frequently with Suzuki engineers and other Suzuki personnel in the United States and in Japan to communicate this information and generally to improve performance and to facilitate testing and evaluation.

There was testimony at trial of initial incredulity on the part of Suzuki engineers concerning Richardson's suspension, of Suzuki's past failures in designing a suspension with the desired characteristics, and of Suzuki's favorable response to the performance of Richardson's suspension. The evidence included internal Suzuki documents made while Suzuki was testing Richardson's suspension, stating that it would "take a long time", perhaps three years, for Suzuki to develop a satisfactory suspension.

In early 1979 Richardson and a colleague Cazort conceived an improvement in the linkage-generated rising rate suspension, which they called the "Alternate Shock Mount" and which they disclosed to Suzuki, accompanied by drawings and blueprints made by Cazort. The difference from the structure described in the '332 patent is that in the Alternate Shock Mount the lower end of the spring is pivotally secured to the swing arm which is pivotally secured to the frame, instead of being pivotally secured directly to the frame, resulting in increased strength.

In May 1979 Richardson's first prototype for Suzuki, wherein Richardson, aided by Cazort, installed his suspension in a Suzuki 1978 production model, was successfully tested in Japan. Testimony at trial included statements attributed to Suzuki's test riders that they could see the bumps but not feel

them, and other commentary evidencing a highly favorable reaction to Richardson's suspension.

It was a stipulated fact that after these tests Suzuki made the decision to place the linkage-generated rising rate suspension system into production, and started development work for this purpose.

On October 16, 1979 Suzuki filed a patent application in Japan. The corresponding United States patent, filed on October 8, 1980, claims the Alternate Shock Mount suspension as disclosed by Richardson, and also claims a modification made by Suzuki called the "criss-cross". Suzuki named two of its engineers, Hirohide Tamaki and Manabu Suzuki, as the inventors.

Suzuki twice requested and was granted one-month extensions of its Option and License Agreement with Richardson. In December 1979 Suzuki informed Richardson that it would not exercise the option.

In March 1980 Suzuki began competitive racing in the United States of Suzuki motorcycles using the Alternate Shock Mount suspension, which Suzuki named the "Full Floater". Suzuki met with marked racing success, the Full Floater receiving favorable publicity and high acclaim from the public. Extensive advertising was directed to the Full Floater rising rate suspension. The product achieved widespread commercial success.

Suzuki denied any obligation to Richardson.

Litigation

Richardson brought suit against Suzuki (Japan) and the U.S. Suzuki Motor Corporation in California state court, and was granted a preliminary injunction restraining the Suzuki companies from breach of the Option and License Agreement and requiring them to comply with the confidentiality terms thereof. At Suzuki's request the state court declined to enforce the injunction after U.S. Suzuki sued Richardson in federal court, seeking a declaratory judgment of invalidity and non-infringement of Richardson's '332 patent.

In 1982 Richardson filed a patent infringement action against the Suzuki companies and others. (Only the Suzuki companies remain as parties.) Richardson reasserted the state claims of breach of contract, breach of implied covenant of good faith and fair dealing, misappropriation of trade secrets, and fraud, and among other relief requested assignment of the patents obtained by Suzuki on the Alternate Shock Mount. Suzuki counterclaimed for fraud and breach of contact by Richardson, based on asserted invalidity of the '332 patent.

The federal actions were consolidated and tried to a jury. After forty-seven days of a two-part trial the jury gave special verdicts on issues of liability and damages. The district court entered final judgment under Fed.R.Civ.P. 54(b) on the jury verdicts that the '332 patent was not invalid and was infringed by Suzuki, that nine of Richardson's eleven asserted trade secrets were not trade secrets, and that Richardson was not entitled to assignment of the Tamaki/Suzuki patents on the Alternate Shock Mount. The court also entered final judgment on the jury verdicts of damages for patent infringement and for Suzuki's use of certain of Richardson's information that the jury found were not trade secrets. The court denied prejudgment interest and attorney fees, and refused to grant an injunction.

The district court denied most of the parties' post-trial motions, but granted Suzuki's motion for a new trial on three issues that the jury had decided in favor of Richardson, upholding two of the eleven asserted trade secrets, finding fraud on the part of Suzuki, and assessing damages for fraud. The district court then entered a supplemental final judgment for immediate appeal of the issues that the court intended to retry, and certified three specific questions on these and related issues.

I

Validity of Richardson's '332 Patent

Suzuki asserts on appeal the invalidity of claim 9 on grounds of anticipation (35 U.S.C. §102) and obviousness (35 U.S.C. §103).[3] The district court, stating that questions of patent validity must be decided by the court, told the jury that its verdicts on this issue were advisory. Nevertheless the court duly entered the jury verdicts, including the answer YES to the question: "Under the facts and law as you believe that you understand them, do you find Claim 9 of the Richardson Patent to be valid?" The court entertained, and denied, post-trial motions for judgment n.o.v. and for a new trial on the question of validity. The court also independently decided the question, upholding validity of the '332 patent.

The record provided to us doesn't show the origin of this discredited procedure of adviso-

[3] The additional aspects of adequacy of disclosure (35 U.S.C. §112) and unenforceability for inequitable conduct, both decided in favor of Richardson, have not been appealed.

ry verdicts, or whether either party objected. In *Perkin-Elmer Corp. v. Computervision Corp.*, 732 F.2d 888, 895 n.5, 221 USPQ 669, 674 n.5 (Fed. Cir.), *cert. denied*, 469 U.S. 857 [225 USPQ 792] (1984), we observed that:

> The view suggested in *Sarkisian [v. Winn-Proof Corp.*, 688 F.2d 647, 651, (9th Cir. 1982), *cert. denied*, 460 U.S. 1052 (1983)], that a jury verdict on nonobviousness is at best advisory, would make charades of motions for directed verdict or JNOV under Fed.R.Civ.P. 50 in patent cases. These motions apply only to *binding* jury verdicts.

Moreover, use of an advisory jury is limited to actions not triable of right by a jury. (emphasis in original, citations omitted). In a similar circumstance wherein the trial court and the jury independently decided the same jury question (in that case the question of willfulness of infringement) we remarked that "'[a]ll fact findings of a jury are nonadvisory, unless made in an area expressly removed from jury verdict." *Shiley, Inc. v. Bentley Laboratories, Inc.*, 794 F.2d 1561, 1568, 230 USPQ 112, 115 (Fed. Cir. 1986), *cert. denied*, 479 U.S. 1087 (1987).

[1] It is established that the jury may decide the questions of anticipation and obviousness, either as separate special verdicts or en route to a verdict on the question of validity, which may also be decided by the jury. *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1547, 220 USPQ 193, 197 (Fed. Cir. 1983):

> No warrant appears for distinguishing the submission of legal questions to a jury in patent cases from such submissions routinely made in other types of cases. So long as the Seventh Amendment stands, the right to a jury trial should not be rationed, nor should particular issues in particular types of cases be treated differently from similar issues in other types of cases.

See also, e.g., Vieau v. Japax, Inc., 823 F.2d 1510, 1515, 3 USPQ2d 1094, 1098 (Fed. Cir. 1987); *Verdegaal Brothers Inc. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1052 (Fed. Cir.), *cert. denied*, 108 S.Ct. 95 (1987); *Data Line Corp. v. Micro Technologies, Inc.*, 813 F.2d 1196, 1200, 1 USPQ2d 2052, 2054 (Fed. Cir. 1987); *Orthokinetics, Inc. v. Safety Travel Chairs, Inc.*, 806 F.2d 1565, 1571, 1 USPQ2d 1081, 1085 (Fed. Cir. 1986); *DMI, Inc. v. Deere & Co.*, 802 F.2d 421, 425–27, 231 USPQ 276, 279–80 (Fed. Cir. 1986); *Mainland Industries, Inc. v. Standal's Patents Ltd.*, 799 F.2d 746, 747–48, 230 USPQ 772, 773 (Fed. Cir. 1986); *Trans-World Mfg. Corp. v. Al Nyman & Sons, Inc.*, 750 F.2d 1552, 1560, 224 USPQ 259, 263 (Fed. Cir. 1984); *Quaker City Gear Works, Inc. v. Skil Corp.*, 747 F.2d 1446, 1454–55, 223 USPQ 1161, 1165–66 (Fed. Cir. 1984), *cert. denied*, 471 U.S. 1136 (1985); *Weinar v. Rollform Inc.*, 744 F.2d 797, 805, 223 USPQ 369, 372 (Fed. Cir. 1984), *cert. denied*, 470 U.S. 1084 (1985); *Perkin-Elmer Corp.*, 732 F.2d at 894–95, 221 USPQ at 674; *Envirotech Corp. v. Al George, Inc.*, 730 F.2d 753, 758, 221 USPQ 473, 477 (Fed. Cir. 1984); *Railroad Dynamics, Inc. v. A. Stucki Company*, 727 F.2d 1506, 1512–13, 220 USPQ 929, 935 (Fed. Cir.), *cert. denied*, 469 U.S. 871 [224 USPQ 520] (1984); *White v. Jeffrey Mining Mach. Co.*, 723 F.2d 1553, 1558, 220 USPQ 703, 705 (Fed. Cir. 1983) ("Submission of such a question of law [obviousness] to a jury, accompanied by appropriate instructions, is proper."), *cert. denied*, 469 U.S. 825 (1984). *See generally*, H.T. Markey in *On Simplifying Patent Trials*, 116 F.R.D. 369, 370 (1987) ("There is neither reason nor authority for employing in a patent trial procedures and practices different from those employed in any other civil trial. Indeed, reason and authority mandate the contrary.")

Although the district court and the jury reached the same result, the standards by which appellate courts review the judgment differ, depending on whether it arose from a jury or a bench trial. *District of Columbia v. Pace*, 320 U.S. 698, 701 (1944) ("findings of fact by an equity court and the verdict of a jury have from time immemorial been subject to different rules of finality"). When the judgment arises from a jury verdict, the reviewing court applies the reasonable jury/substantial evidence standard: a standard that gives greater deference to the judgment simply because appellate review is more limited, compared with review of a trial judge's decision. *Id.* at 702. As summarized in *Lavender v. Kurn*, 327 U.S. 645, 653 (1946), "the appellate court's function is exhausted when that evidentiary basis [of the jury's verdict] becomes apparent, it being immaterial that the court might draw a contrary inference or feel that another conclusion is more reasonable." *See generally* M.B. Louis, *Allocating Adjudicative Decision Making Authority Between the Trial and Appellate Levels: A Unified View of the Scope of Review, The Judge/Jury Question, and Procedural Discretion*, 64 N.C. L.Rev. 993 (1986).

The parties do not take a position on the district court's procedure, but appear to recognize that the issue of validity was properly for jury determination, for neither party refers to the district court's explanation of its

independent determination of the question of obviousness.

In the interest of reaching an end to this protracted litigation, we have reviewed the judgment on the terms on which it reaches us. We have determined first whether Suzuki met its burden of showing on appeal that no reasonable jury could have reached the verdict of "valid" on the evidence before it. *Allen Organ Co. v. Kimball Int'l, Inc.*, 839 F.2d 1556, 1566, 5 USPQ2d 1769, 1777 (Fed. Cir.), *cert. denied*, 109 S.Ct. 132 (1988); *DMI, Inc. v. Deere & Co.*, 802 F.2d 421, 425, 231 USPQ 276, 278 (Fed. Cir. 1986); *Shatterproof Glass Corp. v. Libbey-Owens Ford Co.*, 758 F.2d 613, 618–19, 225 USPQ 634, 636 (Fed. Cir.), *cert. dismissed*, 474 U.S. 976 (1985). Then, on the premise that the parties may have waived their right to a jury trial on this question by failure to object to the district court's procedure, we have considered whether the district court's independent judgment of validity may be sustained, on the standards applicable thereto. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1566–68, 1 USPQ2d 1593, 1595–97 (Fed. Cir.) (obviousness determination in bench trial reviewed as a question of law based on underlying facts), *cert. denied*, 107 S.Ct. 2187 (1987).

The court correctly instructed the jury that invalidity must be proved by clear and convincing evidence, referring to the presumption of validity. *Perkin-Elmer Corp.*, 732 F.2d at 894, 221 USPQ at 674; *Jamesbury Corp. v. Litton Industrial Products, Inc.*, 756 F.2d 1556, 1559, 225 USPQ 253, 255 (Fed. Cir. 1985); *American Hoist & Derrick Co. v. Sowa & Sons, Inc.*, 725 F.2d 1350, 1360, 220 USPQ 763, 771 (Fed. Cir.), *cert. denied*, 469 U.S. 821 [224 USPQ 520] (1984).

A. Anticipation

The district court correctly instructed the jury that an invention is anticipated if the same device, including all the claim limitations, is shown in a single prior art reference. Every element of the claimed invention must be literally present, arranged as in the claim. *Perkin-Elmer Corp.*, 732 F.2d at 894, 221 USPQ at 673; *Kalman v. Kimberly-Clark Corp.*, 713 F.2d 760, 771–72, 218 USPQ 781, 789 (Fed. Cir. 1983), *cert. denied*, 465 U.S. 1026 [224 USPQ 520] (1984). The identical invention must be shown in as complete detail as is contained in the patent claim. *Jamesbury Corp.*, 756 F.2d at 1560, 225 USPQ at 256; *Connell*, 722 F.2d at 1548, 220 USPQ at 198.

As prior art, Suzuki relied on the motorcycle suspensions described in certain patents to Downs and Warner, and on the race car wheel suspensions described for Tyrrell and McLaren race cars in two Road and Track magazine articles. Witnesses explained to the jury the similarities and differences between the invention of the '332 patent and each prior art reference. For example, the Downs suspension has a spring element that is rigidly attached to the motorcycle frame and does not pivot as is required by claim 9 of the '332 patent. The Warner reference shows a suspension having a bell crank that is pivotally mounted to the motorcycle frame but not at an intermediate point, whereas Richardson requires a mid-point pivot of the bell crank to the frame. Neither Downs nor Warner describes a rising rate. The magazine articles describe a four wheel racing car suspension system having a linkage-generated variable rising rate incorporating a bell crank, but instead of the swing arm of Richardson's motorcycle suspension, the race car systems use an A-shaped arm mounted to the side of an upright wheel; and the bell crank and linkage in the race car system is located beside the wheel, rather than in front of the wheel as in Richardson's motorcycle system.

Witnesses testified that rising rate in motorcycles had previously been obtained only by progressively wound springs and gas operated shock absorbers. Suzuki argued that rising rate is inherent in the Downs and Warner motorcycle suspensions and expressly described for race cars in the magazine articles, and also that rising rate is merely a statement of function, and thus should not be a basis for distinction from the prior art.

The jury found that Downs did not "disclose each and every element of the Richardson Claims 1 and 9 or their equivalent". For the Warner reference, the jury could not reach a unanimous verdict on this same question, but answered NO to the question whether "the respective elements of Warner function in substantially the same way as the corresponding elements in Richardson to produce substantially the same results". The jury found that the race car suspensions did "disclose each and every element of the Richardson Claims 1 and 9 or their equivalent", but did not reach a unanimous verdict as to whether they "function in substantially the same way as the corresponding elements in Richardson to produce substantially the same results."

The jury had erroneously been instructed that anticipation may be shown by equivalents, a legal theory that is pertinent to obviousness under Section 103, not to antici-

pation under Section 102. *Lewmar Marine, Inc. v. Barient, Inc.*, 827 F.2d 744, 747–48, 3 USPQ2d 1766, 1768 (Fed. Cir. 1987), *cert. denied*, 108 S.Ct. 702 (1988); *Connell*, 722 F.2d at 1548, 220 USPQ at 198. The jury requested a definition of "equivalent" during its deliberations, and was given the Webster's dictionary definition "corresponding or virtually identical, especially in effect or function." This narrow definition, which does not accord with that of *Graver Tank & Mfg. Co. v. Linde Air Products Co.*, 339 U.S. 605, 608 [85 USPQ 328, 330] (1950), may have minimized the legal error in the instructions. In any event, the erroneous inclusion of equivalents in the anticipation inquiry favored Suzuki. The jury nonetheless answered YES to the special verdict: "Under the facts and law as you believe that you understand them, do you find Claim 9 of the Richardson Patent to be valid?"

[2] On the totality of the evidence and in light of the jury instructions and answers, we conclude that a reasonable jury could have found that the patent was not invalid on grounds of anticipation. *Perkin-Elmer Corp.*, 732 F.2d at 894, 221 USPQ at 673–74 (review of presumed jury finding that anticipation not proved, based on jury verdict of validity).

Reviewing the analysis and decision of the district court, based on the same prior art, we discern no clear error in the court's conclusion that claim 9 was not invalid.

We affirm that claim 9 was not proved invalid on the ground of anticipation.

B. Obviousness

The issue of obviousness was vigorously litigated, Suzuki relying on the same Downs and Warner patents and magazine articles. The record shows that there was extensive testimony concerning the differences between Richardson's suspension and the prior art. Suzuki argued at trial, and repeats on this appeal, that these differences are trivial mechanical expedients.

The jury, among its special verdicts on the *Graham* factors, found that a person of ordinary skill in the pertinent art could be any of: (1) a motorcycle mechanic without formal technical education, (2) a person with experience in working on suspension systems for racing automobiles, but without formal technical training, (3) suspension system instructors, (4) professional motorcycle riders, and (5) someone possessing above-average mechanical skills. Suzuki argues that such a person is of generally high mechanical skill, and to such a person Richardson's rising rate motorcycle suspension would have been an obvious "adaption" of the race car suspension systems, which "suggests itself quite plainly, since Downs and Warner incorporate bell cranks in their respective suspensions."

The jury was unable to reach a unanimous verdict on the question of whether a person of the level of skill found by the jury, presented with the problem and being familiar with all the prior art including these four specific references, but unaware of Richardson's device, would be "led to do" what Richardson did. In response to the ultimate question, as we have observed, the jury reached the unanimous verdict that "Under the facts and law as you believe that you understand them", claim 9 was "valid". The district court entered judgment on the jury verdicts, independently held the patent valid, and denied Suzuki's motions for judgment n.o.v. and for a new trial on the issue of validity.

The question for the jury was whether the challenger met the burden of proving invalidity by clear and convincing evidence; and the question on review is whether reasonable jurors could have concluded that the challenger failed to meet that burden. *Orthokinetics, Inc. v. Safety Travel Chairs, Inc.*, 806 F.2d 1565, 1571, 1 USPQ2d 1081, 1085 (Fed. Cir. 1986); *Perkin-Elmer Corp.*, 732 F.2d at 894–95, 221 USPQ at 674. The jury's lack of unanimity on certain special verdicts can reasonably be taken to mean, as the district court held, that invalidity had not been proved by clear and convincing evidence.

[3] Our review shows that there was substantial evidence on which reasonable jurors could have concluded that claim 9 had not been proved invalid for obviousness, and thus reached the verdict of "valid". Although the district court erred in its belief that obviousness could only be presented to the jury for an advisory verdict, we may view the court's agreement with the jury verdict of validity as supporting the court's denial of Suzuki's post-trial motions for judgment n.o.v. and for a new trial. *Perkin-Elmer Corp.*, 732 F.2d at 895, 221 USPQ at 674–75. However it is viewed procedurally, no reversible error has been shown in the court's conclusion that obviousness had not been proved and that claim 9 was not invalid.

The judgment of validity is affirmed.

II

Infringement

Richardson bore the burden of proving infringement by a preponderance of the evi-

dence. The district court correctly stated that the jury was the finder of the fact of infringement.

The jury rendered special verdicts as to the Suzuki motorcycles before it, Model M having the Richardson/Cazort Alternate Shock Mount and Model C having the "criss-cross" connection added by Suzuki, as follows:

> 9(a). Do defendant Suzuki's motorcycles of the Model M type . . . infringe Claim 9 of the plaintiff's patent?
>
> Answer: YES, WITH THE RISING RATE
>
> 9(b). Do defendant Suzuki's motorcycles of the Model C type . . . infringe Claim 9 of the plaintiff's patent?
>
> Answer: YES, WITH THE RISING RATE

In subparts 9(a)(2) and 9(b)(2) of the special verdict the jury answered YES to the question whether the Suzuki motorcycles produce substantially the same rising rate as taught in Richardson's patent.

The principal question on appeal is the meaning and effect of the jury answers to subparts (1) of the special verdict, which were directed "in particular" to the Alternate Shock Mount and the criss-cross modifications:

> 9(a)(1). In particular, is the defendant's linkage equivalent to the plaintiff's, bearing in mind that the bottom of the spring in the former is affixed to the swing arm rather than to the frame?
>
> Answer: NO
>
> 9(b)(1). In particular, is the defendant's linkage equivalent to the plaintiff's, in light of the "criss-cross" of the connecting rods and the bell crank in the defendant's model, as well as the spring attachment to the swing arm, as compared with the plaintiff's Claim 9?
>
> Answer: NO

The district court entered judgment of infringement in favor of Richardson and denied post-trial motions by both sides, including a motion by Richardson to reopen the record in order to present evidence on the doctrine of equivalents. The district court stated that the jury verdicts mean that "infringement is limited to 'rising rate'" and that the Suzuki and Richardson linkages are not equivalent.

Suzuki argues that special verdicts 9(a)(1) and 9(b)(1) require judgment of non-infringement; or, as a minimum, that these verdicts are inconsistent with the verdicts of infringement in 9(a) and 9(b), such that a new trial is required of the entire issue. Richardson states that the verdicts can be understood, when viewed in light of the jury instructions, in a way that supports the judgments of infringement. Suzuki did not request a new trial on the basis of inconsistent verdicts at the time the judgments were entered, while Richardson moved, unsuccessfully, to amend or delete verdicts 9(a)(1) and 9(b)(1). Each party asserts that any inconsistency should be resolved in its favor.

The Ninth Circuit, in accordance with the general rule, requires trial and appellate courts to seek reconciliation of apparently inconsistent verdicts:

> When faced with a claim that verdicts are inconsistent, the court must search for a reasonable way to read the verdicts as expressing a coherent view of the case, and must exhaust this effort before it is free to disregard the jury's verdict and remand the case for a new trial.

Toner v. Lederle Laboratories, 828 F.2d 510, 512 (9th Cir. 1987), *cert. denied*, 108 S.Ct. 1122 (1988) (citing *Gallick v. Baltimore & Ohio R.R.*, 372 U.S. 108, 119 (1963), also citing *Atlantic & Gulf Stevedores, Inc. v. Ellerman Lines, Ltd.*, 369 U.S. 355, 364 (1962) and *Blanton v. Mobil Oil Corp.*, 721 F.2d 1207, 1213, (9th Cir. 1983), *cert. denied*, 471 U.S. 1007 (1985)). *See also Allen Organ Co.*, 839 F.2d at 1563, 5 USPQ2d at 1775 (the appellate court must make every effort to harmonize the jury's answers).

The district court did not find the special verdicts inconsistent, apparently in the belief that the jury limited infringement to the rising rate provision of claim 9 but not the other claim clauses. This accords with the court's statement to the jury that the infringement was "minor" because it was limited to the rising rate. This interpretation pleased neither party. If we have correctly understood it, it is incorrect as a matter of law.

"We are bound to find the special verdicts consistent if we can do so under a fair reading of them." *Toner*, 828 F.2d at 512. A fair reading of the special verdicts results from simply applying the rule that "[t]he consistency of the jury verdicts must be considered in light of the judge's instructions to the jury". *Toner*, 828 F.2d at 512. The instructions on infringement, and the specific questions asked by special verdict, were designed to resolve the issues raised at trial. There was testimony on both sides of Suzuki's assertion that its suspension was not the same as Richardson's because it produced a different rising rate. We referred *supra* to special verdicts 9(a)(2) and 9(b)(2):

> 9(a)(2). Does defendant's Model M produce rising rate substantially the same as

the rising rate produced under the teachings of the plaintiff's patent?

Answer: YES

9(b)(2). Does defendant's Model C produce rising rate substantially the same as the rising rate produced under the teachings of the plaintiff's patent?

Answer: YES

Another special verdict in the infringement section asked the jury:

11. Does claim 9 of the Richardson Patent describe the invention of a rising rate in terms of what the invention will do rather than in terms of physical arrangement?

Answer: NO

We conclude that the answer "yes, with the rising rate" in verdicts 9(a) and 9(b) is the jury's response to Suzuki's argument, rather than as a finding that only the rising rate claim limitation, and no other, is embodied in the Suzuki suspensions.

We discern no support in the record for the district court's conclusion that verdicts 9(a) and 9(b) meant that the rising rate was the only area of infringement. Structure corresponding to every element of every clause of claims 1 and 9 was identified by witnesses as embodied in the accused motorcycles. There was no real dispute that of the nine or eleven elements in these claims (depending on how counted), all but one were literally present. The dispute centered on one element, the attachment of the spring in the claim clause "spring means having a first end pivotally secured to said frame", since this was the clause affected by the modifications of the Alternate Shock Mount and the criss-cross. In the Alternate Shock Mount, as we have discussed, the spring is pivotally secured to a swing arm that in turn is pivotally secured to the frame, instead of being pivotally secured directly to the frame as is shown in the '332 specification.

Richardson argues that the spring can be either directly or indirectly pivotally secured to the frame, without avoiding literal infringement of the claim. Richardson alternatively argues that on a correct definition of the doctrine of equivalents, citing *Graver Tank*, 339 U.S. at 608 [85 USPQ at 330], these securements are equivalent because the structures are substantially the same and perform substantially the same function in the same way.

The jury had been given the dictionary definition that "equivalent" means "corresponding or virtually identical, especially in effect or function". This definition was reinforced by the phrasing of verdicts 9(a)(1) and 9(b)(1), wherein the question itself instructed the jury on the difference between the linkages, while remaining silent on the similarities.

This presentation was highly prejudicial. Indeed, these verdicts well illustrate the truism that the way a question is asked can direct the answer. "The decision to submit interrogatories, and the precise language in which they are couched, can have an untoward effect on a verdict, if certain elements of the trial or the evidence are thereby overly emphasized in the jury's mind." *Weinar v. Rollform Inc.*, 744 F.2d 797, 809, 223 USPQ 369, 376 (Fed. Cir. 1984), *cert. denied*, 470 U.S. 1084 (1985).

Further, and equally prejudicial, special verdicts 9(a)(1) and 9(b)(1) isolated this specific claim element so that it was removed from the perspective that is obtained only when the claimed invention is viewed in its entirety. *See, e.g., Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 1363, 219 USPQ 473, 482 (Fed. Cir. 1983). We recently reemphasized in *United States Steel Corp. v. Phillips Petroleum Co.*, No. 88-1166, -1167, -1168, -1169, -1170, -1171, slip op. at 13-14 [9 USPQ2d 1461] (Fed. Cir. Jan. 10, 1989), in discussing *Graver Tank*, that there is no error in considering "the principle of the claimed invention".

A device that embodies improvements on a claimed structure does not automatically avoid the reach of the claim. *See, e.g., Atlas Powder Co. v. E.I. du Pont de Nemours & Co.*, 750 F.2d 1569, 1580, 224 USPQ 409, 417 (Fed. Cir. 1984) (separately patentable improvement may also be an equivalent under the doctrine of equivalents); *A.B. Dick Co. v. Burroughs Corp.*, 713 F.2d 700, 703 218 USPQ 965 967-68 (Fed. Cir. 1983) (infringement not avoided "merely by adding elements"), *cert. denied*, 464 U.S. 1042 (1984). Each case must be decided on its particular facts, viewing the changes in the accused structure in light of the claimed invention. *See generally Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 934-35, 4 USPQ2d 1737, 1739 (Fed. Cir. 1987), *cert. denied*, 108 S.Ct. 1226 (1988), and *cert. denied*, 108 S.Ct. 1474 (1988); *Texas Instruments, Inc. v. United States Int'l Trade Comm'n*, 805 F.2d 1558, 1569-70, 231 USPQ 833, 840 (Fed. Cir. 1986), *reh'g denied*, 846 F.2d 1369, 6 USPQ2d 1886 (Fed. Cir. 1988);

[4] We conclude that the jury verdicts, viewed in light of the instructions, held that the Suzuki motorcycles with a rising rate infringed claim 9. We also conclude that on correct instructions no reasonable jury could have found that the claimed invention and the accused structures are not equivalent, on the established facts of record, applying the

correct law of *Graver Tank*. *See Anderson v. Liberty Lobby, Inc.*, 477 U.S. 242, 252 (1986) ("The mere existence of a scintilla of evidence in support of the plaintiff's position will be insufficient; there must be evidence on which the jury could reasonably find for the plaintiff."); *Pullman-Standard v. Swint*, 456 U.S. 273, 291–92 (1982) ("where findings [by the district court] are infirm because of an erroneous view of the law, a remand is the proper course unless the record permits only one resolution of the factual issue"); *Dana Corp. v. IPC Limited Partnership*, 860 F.2d 415, 419, 8 USPQ2d 1692, 1696 (Fed. Cir. 1988) (when there are sufficient established facts of record, appellate court has discretion to determine the merits of JNOV motion.)

The jury verdicts of infringement are supported by substantial evidence, and are upheld. The judgment of infringement is affirmed.

III
Damages for Patent Infringement

As damages for patent infringement the jury assessed a royalty of fifty cents per motorcycle. Richardson states that this royalty is unreasonably low, and resulted from erroneous and prejudicial jury instructions. We review the award on the reasonable jury/substantial evidence standard. *Shatterproof Glass Corp.*, 758 F.2d at 627–28, 225 USPQ at 643–44.

The court told the jury: "Now, I will sustain, I will uphold your verdict [of infringement], but in determining damages and determining any royalty, it seems to me that you must consider that the infringement was a relatively minor infringement." This instruction derived, as we have discussed, from the erroneous interpretation of the verdicts as limited to the "rising rate" clause. We must determine whether this erroneous instruction was prejudicial to the jury's assessment of damages. The Ninth Circuit has stated that "we will reverse a judgment because of a mistake in jury instructions only if the error was prejudicial." *Smiddy v. Varney*, 665 F.2d 261, 265 (9th Cir. 1981), *cert. denied*, 459 U.S. 829 (1982).

35 U.S.C. §284 provides that damages shall be "adequate to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by the infringer". *Fromson v. Western Litho Plate and Supply Co.*, 853 F.2d 1568, 1574, 7 USPQ2d 1606, 1612 (Fed. Cir. 1988). The jury was told that a royalty of $2.00 per motorcycle with an annual minimum of $70,000 had been agreed to by Suzuki and Richardson in the Option and License Agreement. There was testimony of much higher royalties paid by others for similar contributions to motorcycles. Suzuki presented testimony that the $2.00 in the agreement does not apply, but should be the starting point for reducing the royalty because the infringement was minor.

[5] We must assume that the jury followed the court's instruction that the infringement was minor. That instruction was a misinterpretation of the jury verdict of infringement, and it usurped the role of the jury. Absent this prejudicial instruction there was no reasonable basis on which reasonable jury could have found that fifty cents was a reasonable royalty.

The judgment of damages for patent infringement is vacated. We remand for retrial of the question.

IV
Richardson's Technical Information

Issues relating to Richardson's technical information were presented at trial on the legal theories of breach of contract and the tort of misappropriation of trade secrets. The district court concentrated on the tort issues in presentation to the jury, apparently accepting Suzuki's position that it had complied with its contractual obligations to Richardson. The court thus required that Richardson prove the existence of legally protectible trade secrets and their misappropriation by Suzuki.

In the only special verdict on the contract issues, the jury found that Suzuki did not violate its duty of good faith and fair dealing in its relationship with Richardson. The jury instructions on the contractual relationship, however, are pertinent to, and intertwined with, the trade secret issues.

A. The Contractual Relationship

In matters of contract law and interpretation we apply the discernable law of the state of California. *Universal Gym Equipment, Inc. v. ERWA Exercise Equipment Ltd.*, 827 F.2d 1542, 1550, 4 USPQ2d 1035, 1040 (Fed. Cir. 1987). At trial Richardson pressed, unsuccessfully, the California law that a covenant of good faith and fair dealing is implied between parties to a contract. *Seaman's Direct Buying Service, Inc. v. Standard Oil Co.*, 38 Cal.3d 752, 768, 686 P.2d 1158, 1166, 206 Cal.Rptr. 354, 363 (1984) ("It is well settled that, in California, the law implies in *every* contract a covenant

of good faith and fair dealing." (Emphasis in original)).

The contract between Richardson and Suzuki was explained at trial, including the clause wherein Suzuki agreed not to use or disclose the "technical information, know-how, inventions, use data, and design specifications" that it received from Richarson. In discussing whether Suzuki was restrained in its post-contract use of Richardson's information, the district court at first instructed the jury that Suzuki was entitled by law "to use the most efficient means, even though they got it from plaintiff", stating that only "valid trade secrets" were subject to the contractual restraints:

> And then after Suzuki's election not to take a license, of course, they were not supposed to use the plaintiff's trade secrets. That's what the contract says. And once again, you're going to have to determine whether these eleven were valid trade secrets. To what extent did the defendant use them, to what extent would the defendant otherwise have developed them.
>
> Now, some of these trade secrets refer to the best alignments and designs. Well, it seems incongruous to say to the defendant they cannot use the best because the best was intentionally disclosed by the plaintiff, and even though experimentation by the defendant surely would have revealed the best as the patent says that it would.
>
> Were the defendants precluded from using the best or were they obliged to use something less efficient. I can't conceive of the defendants not being entitled to use the most efficient means, even though they got it from the plaintiff.

The court later qualified this position by referring to reverse engineering as being improper — although it is far from clear what a reasonable jury would have understood from the court's instructions:

> But on further reflection, I have to acknowledge that if you find there was a confidential relationship or contract that prohibited Suzuki from using the plaintiff's trade secrets, technical information or know-how, inventions or use data that the plaintiff gave them, unless it exercised the option, if you find those things to be true, I suppose it would be improper for Suzuki to reverse engineer from Richardson's prototypes, or from trade secrets or other information that he gave them.
>
> The defense of reverse engineering does not apply to information received in confidence or whereas here the information is given under a contract.

Reviewing these instructions in the context of the contract and trade secret questions that were before the jury, we conclude that the jury was incorrectly instructed on the law. *See Bulgo v. Munoz*, 853 F.2d 710, 714 (9th Cir. 1988) (quoting *Los Angeles Memorial Coliseum Comm'n v. National Football League*, 726 F.2d 1381, 1398 (9th Cir.), *cert. denied*, 469 U.S. 990 (1984)) (instructions reviewed to determine "whether, viewing the jury instructions as a whole, the trial judge gave adequate instructions on each element of the case to ensure that the jury fully understood the issues.")

[6] In *Universal Gym Equipment*, 827 F.2d at 1549, 4 USPQ2d at 1040, we affirmed liability under California law based on breach of contract, when the parties contracted to limit the use by the recipient of "features, designs, technical information, or know-how" disclosed under the contract. We also affirmed that such a contractual arrangement is not incompatible with the patent law, *id.* at 1550, 4 USPQ at 1041, an issue on which the district court in Richardson's case also appears to have been misled, and to have misled the jury. *See Components for Research, Inc. v. Isolation Products, Inc.*, 241 Cal.App.2d 726, 730, 50 Cal.Rptr. 829, 832 (Cal. Dist.Ct.App. 1966) ("The judgment here but affords protection against the use of plaintiff's trade secrets by those to whom they had been disclosed in confidence. Whether the idea was patented or not, plaintiff is entitled to such protection").

The district court erred in law, in limiting the scope of protected information beyond that set forth in the contract, and in its instructions to the jury as to Suzuki's obligations. These errors are reflected in the trade secret issues.

B. The trade secret issues

The jury, despite the excessively restrictive instructions on what were trade secrets, found that certain items that Suzuki had received from Richardson were trade secrets and had been misappropriated, and assessed damages therefor. The jury also assessed damages for use by Suzuki of certain other items that did not "rise to the dignity of trade secrets", in the words of the special verdicts.

Richardson specified eleven items that he had disclosed to Suzuki under the contract, and that he asserted to be trade secrets; to wit: (1) the optimal characteristics of a motorcycle rear-wheel suspension shock absorber, showing three external adjustments, (2) engineering drawings of his proposed and furnished suspension systems; (3) 1978 and

1979 Suzuki motorcycles modified by Richardson with his rising rate suspension, (4) specific force-velocity curves needed to obtain the advantages of Richardson's invention in Suzuki's motorcycles, (5) design modifications to extend rear wheel travel over earlier rising-rate designs, (6) design of the Alternate Shock Mount including drawings and knowhow, (7) the optimum use and types of certain bearings in the suspension, (8) motorcycle testing and tuning criteria, (9) his bell crank designs and design criteria, (10) adjustments in the angles and dimensions of the parts of the suspension and their effect on performance, and (11) the straight line tubular motorcycle frame.

The California law of trade secrets follows the Restatement definition:

> A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it. . . . Generally it relates to the production of goods, as, for example, a machine or formula for the production of an article.

By-Buk Co., 163 Cal.App.2d at 166, 329 P.2d at 152, 118 USPQ at 553, citing Restatement (First) of Torts, §757 comment b (1939). The court in *By-Buk Co.* reaffirmed "plaintiff's right not to have its [trade secret] processes wrongfully disclosed to others and used to its detriment." *Id.* at 167, 329 P.2d at 153, 118 USPQ at 553.

The burden of proof was placed on Richardson to prove that his information met the legal requirements of a protectible trade secret. *Forro Precision, Inc. v. International Business Machines Corp.*, 673 F.2d 1045, 1056-57, 215 USPQ 299, 305-6 (9th Cir. 1982). This in turn required "either a covenant or a confidential relationship" as a premise of relief. *Futurecraft Corp. v. Clary Corp.*, 205 Cal.App.2d 279, 283, 23 Cal.Rptr. 198, 207-208 (Cal. Dist.Ct.App. 1962) (discussing elements of trade secret protection). Richardson met this requirement through his contractual covenant.

The district court told the jury, several times, that because Suzuki might have developed or could have developed on its own the information it received from Richardson, such information can not be protected as a trade secret. The court said: "Now I think we must assume that the defendant could have accomplished whatever the plaintiff may have contributed toward the development of Models M and C." Whatever the validity of the proposed assumption as to Suzuki's abilities, the court's conclusion is contrary to California law:

> It is not necessary in order that a process of manufacture be a trade secret that it be patentable or be something that could not be discovered by others by their own labor and ingenuity.

By-Buk Co., 163 Cal.App.2d at 166, 329 P.2d at 152, 118 USPQ at 553. Nor does the possibility of independent discovery relieve Suzuki of liability:

> "[S]ecret formulas and processes * * * are property rights which will be protected by injunction, not only as against those who attempt to disclose or use them in violation of confidential relations or contracts express or implied, but as against those who are participating in such attempt with knowledge of such confidential relations or contract, though they might in time have reached the same result by their own independent experiments or efforts."

Id. at 167, 329 P.2d at 153, 118 USPQ at 553-54 (quoting *Herold v. Herold China & Pottery Co.*, 257 F. 911, 913 (6th Cir. 1919)). Indeed, Suzuki did not argue that it had actually developed on its own the information that it first received from Richardson. Although Richardson adduced evidence that Suzuki had been unable to solve this problem, it is not relevant what Suzuki might have been able to do on its own. Ninth Circuit law upholds trade secret status even had the same information been obtainable from other sources. *Clark v. Bunker*, 453 F.2d 1006, 1010, 172 USPQ 420, 423 (9th Cir. 1972) (trade secrecy "is not negated because defendant by an expenditure of effort might have collected the same information from sources available to the public.") (footnote omitted).

The court also erroneously instructed the jury that "slavish" copying is necessary for misappropriation, and that an exercise of independent judgment would remove the information from protection. The court instructed the jury to consider: "Were they secrets. And, second, did the defendants slavishly use them or did they make up their own minds." These views are contrary to California law. "[D]efendants cannot escape responsibility by showing that they have improved upon or modified the plaintiff's process." *By-Buk Co.*, 163 Cal.App.2d at 169, 329 P.2d at 154, 118 USPQ at 554. The court observed in *Sinclair v. Aquarius electronics, Inc.*, 42 Cal.App.3d 216, 222, 116 Cal.Rptr. 654, 659, 184 USPQ 682, 684 (Cal. Ct.App. 1974) that minor variations are to be expected.

Suzuki argued to the jury, and repeats on appeal, that information that Richardson developed after issuance of the '332 patent, including the Alternate Shock Mount, is

barred from trade secret status because it was generally disclosed in Richardson's patent or known to the general public, or because it merely implements the patented invention.

The legal status of information and improvements made after a patent application has been filed is independent of the presence, or absence, of the patent application or ensuing patent. The information and improvements may be separately patentable; they may be preserved in confidence and disclosed only in accordance with agreement; and they are protected against misappropriation in accordance with the laws of contract and tort. The court misstated the law in telling the jury that the jury could decide whether Richardson could have both a valid patent and legal protection for later-developed information on the patented invention:

> So on the one hand [Richardson] says the ordinary person skilled in the art can take this patent and use it and make a machine based upon it. But, on the other hand, he says, however, the experimentation and the ability to do this constitutes trade secrets for which you must pay me. Now, that constitutes a dilemma and it's up to you to determine the extent to which Mr. Richardson may claim as trade secrets things that the ordinarily prudent person skilled in the art should be able to do on his own.

The district court's phrase "should be able to do on his own" may explain its misperception of the law. It is not known what Suzuki was able to do on its own, for Suzuki not only sought Richardson's knowhow, improvements, data, and information, but also agreed to respect the confidentiality thereof. This information is intellectual property in the eyes of the law, and is protected in accordance with law. *See generally Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 493 [181 USPQ 673, 682] (1974). *See also Components for Research, Inc.*, 241 Cal. App.2d at 730, 50 Cal.Rptr. at 832 (whether the product design was patented or not, plaintiff is entitled to trade secret protection for manufacturing process); *Sinclair*, 42 Cal. App.3d at 225, 116 Cal.Rptr. at 660, 184 USPQ at 686 ("Trade secret law encourages invention in areas where patent law does not reach"). *Accord Thermotics, Inc. v. Bat-Jac Tool Co., Inc.*, 541 S.W.2d 255, 261, 193 USPQ 249, 253 (Tex. Civ.App. 1976) (post-patent improvement protectable under trade secret law); *Franke v. Wiltschek*, 209 F.2d 493, 495, 99 USPQ 431, 433 (2d Cir. 1953) (immaterial that defendants could have derived trade secrets from expired patent).

[7] It is apparent that the court imposed a higher standard for trade secret status than is contained in California law. The court's instructions, commentary, and phrasing of the special verdicts not only placed a prejudicially heavy burden on Richardson, but also demeaned the information itself.

Despite this prejudicial environment, the jury found that items 5 and 6 were trade secrets and had been misappropriated by Suzuki, and assessed damages therefore. The jury also found that items 1–4 and 7–11 were not trade secrets, and that for some but not all of these items compensation should be awarded based on "benefit from the plaintiff's knowledge and from the time and effort expended by him".

The district court granted Suzuki's motion for a new trial with respect to items 5 and 6, and upheld the jury verdicts with respect to items 1–4 and 7–11.

C. The new trial of items 5 and 6

The grant of a new trial is ordinarily not reviewable, but on this issue the district court entered final judgment for purposes of appeal, and certified three questions. The first certified question is:

> 1. Where the plaintiff's asserted trade secrets Nos. 5 and 6: (a) Actually valid proprietary trade secrets, as the jury found and awarded very substantial royalties; or (b) Did the plaintiff's contributions in these respects represent no more than the services of a skilled mechanic, which readily could have been duplicated by the defendant, and which entitled the plaintiff only to quantum meruit compensation, as the court believes; or (c) Were the plaintiff's contributions no more than those contemplated under the option agreement and paid for by the defendant, as the defendant contends?

We respond to this question: From the record before us the jury verdict that items 5 and 6 met the requirements for trade secret protection was supported by the great weight of the evidence. Richardson and Cazort testified about the design modifications that were the subject of item No. 5 and the Alternate Shock Mount subject of item No. 6. The Alternate Shock Mount was considered sufficiently novel and valuable that Suzuki included it in a patent application filed in Japan and later in the United States. The record does not negate the jury's determination of the value of this information. According to California law it is immaterial what Suzuki could have done, for it chose to use Richardson's information, which it obtained under restraint.

In further response, we remark that the relation between the parties, set by contract, was a routine commercial arrangement wherein Richardson agreed to facilitate Suzuki's testing and evaluation of Richardson's invention. This did not convert Richardson's work in adapting his invention to Suzuki's motorcycle into the work of a hired technician whose work product was automatically owned by Suzuki. The proprietary nature of the work done and information provided by Richardson was established by agreement, as was the agreement that Suzuki would not use this information if it did not exercise its option.

[8] There was substantial evidence before the jury that the information on items 5 and 6 was not publicly known, that Suzuki agreed to receive and preserve it in confidence, and that the information fully satisfies the statutory and jurisprudential requirements for protectible trade secrets.

In order to vacate the jury's verdict upholding items 5 and 6 as trade secrets and grant a new trial thereon, the trial court must find that the jury's verdict "is contrary to the clear weight of the evidence, or is based upon evidence which is false, or to prevent, in the sound discretion of the trial judge, a miscarriage of justice." *Hanson v. Shell Oil Co.*, 541 F.2d 1352, 1359 (9th Cir. 1976), *cert. denied*, 429 U.S. 1074 (1977) (quoting *Moist Cold Refrigerator Co. v. Lou Johnson Co.*, 249 F.2d 246, 256, 115 USPQ 160, 168–69 (9th Cir. 1957), *cert. denied*, 356 U.S. 968 [117 USPQ 498] (1958)); *William Inglis & Sons Baking Co. v. ITT Continental Baking Co., Inc.*, 668 F.2d 1014, 1027 (9th Cir. 1981), *cert. denied*, 459 U.S. 825 (1982). It is insufficient that the district court would simply have reached a different verdict.

Our review requires determination of whether the district court abused its discretion in its decision to grant the new trial. *Id. See Transgo, Inc. v. Ajac Transmission Parts Corp.*, 768 F.2d 1001, 1014, 227 USPQ 598, 602 (9th Cir. 1985), *cert. denied*, 474 U.S. 1059 (1986) ("the grant or denial of either a motion for a new trial or a motion to amend the judgment must be reviewed on the basis of a determination of whether the district court abused its discretion.") *See generally Seattle Box Co. v. Industrial Crating & Packing, Inc.*, 756 F.2d 1574, 1581, 225 USPQ 357, 363 (Fed. Cir. 1985) ("Abuse of discretion may be established by showing that the district court either made an error of law, or a clear error of judgment, or made findings which were clearly erroneous.") The district court's statements, for example with respect to item 5, "I simply cannot conclude that that is a trade secret. It was an attempt to help Suzuki adapt the Richardson concept to the Suzuki machine ....", reflect an error of law.

Despite the legal error in the instructions, as we have discussed, any prejudice resulting therefrom favored Suzuki, not Richardson. We conclude that the district court exceeded its discretionary authority in vacating the jury verdict and ordering a new trial. That action is reversed, and the jury verdict is reinstated as to items Nos. 5 and 6, including the damages assessed for items Nos. 5 and 6.

D. Items 1–4 and 7–11

For asserted trade secrets Nos. 1–4 and 7–11, the jury may well have been led by erroneous instructions into applying an incorrect legal standard, in finding that these items were not trade secrets. It appears, however, that Richardson did not move for judgment n.o.v. or a new trial on these verdicts. Although there is a hint in the post-trial colloquy that the court intended or was willing to retry all the trade secret issues along with items 5 and 6, this does not satisfy the rule, supported by logic, that the formalities of post-trial motions be respected. *Snellman v. Ricoh Co.*, 836 F.2d 528, 534, 5 USPQ2d 1341, 1346 (Fed. Cir. 1987) (applying Ninth Circuit law in holding that motions for judgment n.o.v. and for a new trial must be made). Thus we have no authority to review these verdicts.

By special verdict the jury was also asked to assess damages for Suzuki's use of the information encompassed in each of items 1–4 and 7–11, even if the information did not "rise to the dignity of trade secrets". The jury determined this sum for each item, some at $0, the highest at $25,000, for a total of $104,000. The district court sustained this award, on a theory of "quantum meruit compensation". Both parties appeal this award, Richardson asserting its inadequacy, and Suzuki arguing that Richardson was fully paid for his information in the option agreement, and is not entitled to damages for Suzuki's use of any information received from Richardson.

We have rejected, as a matter of law, Suzuki's theory that it is entitled to use, free, the information disclosed by Richardson under the option agreement. Richardson's disclosures were made under terms that prohibited their use by Suzuki if the option was not exercised. This contract provision does not depend on whether the information is a trade secret, but only on whether it was previously known to Suzuki or generally known to the public, as discussed *ante*.

An appellate tribunal is abjured to determine whether a jury verdict can be sustained, on any reasonable theory. *Jaffke v. Kunham*, 352 U.S. 280, 281 (1957) ("A successful party in the District Court may sustain its judgment on any ground that finds support in the record.")

[9] There was substantial evidence at trial whereby a reasonable jury could have determined the sums awarded by this jury. Indeed, Suzuki does not challenge the valuations of the damage awards for items 1–11, arguing instead that nothing at all is owing.

The judgment as to items 1–4 and 7–11 is affirmed, including damages assessed for these items in the total amount of $104,000.

V
Injunction

The district court, having entered final judgment that the Suzuki Full Floater suspension infringed claim 9 of the '332 patent, denied Richardson's motion for injunction.

[10] Infringement having been established, it is contrary to the laws of property, of which the patent law partakes, to deny the patentee's right to exclude others from use of his property. 35 U.S.C. §261. "[T]he right to exclude recognized in a patent is but the essence of the concept of property". *Connell*, 722 F.2d at 1548, 220 USPQ at 198 (citing *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983)).

It is the general rule that an injunction will issue when infringement has been adjudged, absent a sound reason for denying it. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 842 F.2d 1275, 1281, 6 USPQ2d 1277, 1283 (Fed. Cir. 1988). Suzuki has presented no such reason. This court stated in *H.H. Robertson Co. v. United Steel Deck, Inc.*, 820 F.2d 384, 390, 2 USPQ2d 1926, 1929–30 (Fed. Cir. 1987), when reviewing an injunction granted *pendente lite*:

> In matters involving patent rights, irreparable harm has been presumed when a clear showing has been made of patent validity and infringement. *Smith International*, 718 F.2d at 1581, 219 USPQ at 692. This presumption derives in part from the finite term of the patent grant, for patent expiration is not suspended during litigation, and the passage of time can work irremediable harm.

We observe that the '332 patent will expire in less than four years, that litigation started over eight years ago, and that the district court remarked that further proceedings could consume "several years".

Further, a misappropriator of trade secrets has no authorization of right to continue to reap the benefits of its wrongful acts. Richardson is entitled to an injunction against Suzuki's continuing use of trade secrets Nos. 5 and 6. *By-Buk Co.*, 163 Cal. App.2d at 167, 329 P.2d at 153, 118 USPQ at 553–54; *Components for Research, Inc.*, 241 Cal.App.2d at 730, 50 Cal.Rptr. at 832.

The denial of Richardson's request for injunction is reversed. On remand the district court shall enter appropriate injunctive relief.

VI
Fraud

The jury found by special verdicts that Suzuki fraudulently induced Richardson to reveal his trade secrets by concealing its intention not to exercise its option or take a license, and that Suzuki fraudulently concealed from Richardson the fact that it was developing the Full Floater "with the intention of declining to exercise the option and then nevertheless to utilize the plaintiff's trade secrets in the full floater". The jury also found fraud in that Suzuki filed the Tamaki patent application "in the knowledge that the invention asserted therein (the spring/swing arm connection) was first disclosed to them by Richardson". The jury awarded Richardson $20,000 in compensatory and $100,000 in punitive damages.

The district court vacated the judgment and ordered a new trial. Suzuki asserts that the court should have granted Suzuki's motion for judgment n.o.v. instead of ordering a new trial, while Richardson asserts that the court should have upheld the jury verdicts.

The district court certified the question of how to treat its belief that Suzuki did not commit the offenses of fraud and concealment found by the jury, including the question of punitive damages. We first must consider whether a reasonable jury could have reached the verdicts here reached. *Lavender v. Kurn*, 327 U.S. at 653. Apt is the statement of the Ninth Circuit in *Crocker-Citizens Nat'l Bank v. Control Metals Corp.*, 566 F.2d 631, 635 (9th Cir. 1977): "Courts are not free to reweigh the evidence and set aside the jury verdict merely because the jury could have drawn different inferences or conclusions or because judges feel that other results are more reasonable", quoting *Cockrum v. Whitney*, 479 F.2d 84, 86 (9th Cir. 1973), in turn quoting *Tennant v. Peoria & P. U. Ry. Co.*, 321 U.S. 29, 35 (1944).

[11] The record shows that there was testimony, based on certain of Suzuki's documents, on which a reasonable jury could have

supported these verdicts. There were issues of credibility, and inferences that could reasonably have been drawn in a manner adverse to Suzuki. "The credibility of witnesses and the weight of the evidence are issues for the jury and are generally not subject to appellate review." *Benigni*, 853 F.2d at 1525. While the district court may have believed that Suzuki did not commit fraud, review shows that the requirements for vacating the jury verdicts and relitigating the issue were not met. *Hanson*, 541 F.2d at 1359; *William Inglis*, 668 F.2d at 1027. A fresh trial is not warranted simply because the district court would have reached a different verdict.

A jury assessment of punitive damages is not excluded in circumstances such as those here presented, where the jury expressly found fraud. *Tri-Tron Int'l v. Velto*, 525 F.2d 432, 437, 188 USPQ 177, 181 (9th Cir. 1975) ("where compensatory damages are sought and awarded, the court has power, on a proper record, to award punitive damages") , citing *Clark v. Bunker* 453 F.2d 1006 1012, 172 USPQ 420, 424 (9th Cir. 1972), in turn citing *El Rancho, Inc. v. First Nat'l Bank*, 406 F.2d 1205, 1218 (9th Cir. 1968), *cert. denied*, 396 U.S. 875 (1969) (jury verdict awarding punitive damages was supported by evidence of malice) and *Davenport v. Mutual Benefit Health & Accident Ass'n*, 325 F.2d 785, 787 (9th Cir. 1963) (remand for trial to allow evidence of fraud to support claim of punitive damages.).

The district court correctly instructed the jury as to the law, stating that "it's only if you find that the defendants' conduct stem from malice, oppression, fraud or bad faith that you can find any punitive damage at all." As stated in *In re Innovative Construction Systems, Inc.*, 793 F.2d 875, 889, 230 USPQ 94, 104 (7th Cir. 1986):

> [A] breach of faith underlies every trade secret claim. However, establishing that breach alone is insufficient to warrant an award of punitive damages; one must also demonstrate that the defendant acted wantonly, willfully, or in reckless disregard of the plaintiff's rights. (Citations omitted)

See also Neal v. Farmers Insurance Exchange, 21 Cal.3d 910, 928, 582 P.2d 980, 986, 148 Cal.Rptr. 389, 395 (1978) ("In order to justify an award of exemplary damages, the defendant must be guilty of oppression, fraud or malice. (Civ. Code §3294.) He must act with the intent to vex, injure or annoy, or with a conscious disregard of the plaintiff's rights") (quoting *Silberg v. California Life Insurance Co.*, 11 Cal.3d 452, 462, 521 P.2d 1103, 1110, 113 Cal.Rptr. 711, 718 (1974)); *Reynolds Metals Co. v. Lampert*, 316 F.2d 272, 275 (9th Cir. 1963), *cert. denied*, 376 U.S. 910 (1964) (in jury trial, evidence to justify punitive damages must show injury was done maliciously or willfully and wantonly or committed with bad motive or recklessly); *Transgo, Inc.*, 768 F.2d at 1024 [227 USPQ at 610] (The determination to award punitive damages was "within the exclusive province of the jury") (quoting *Runge v. Lee*, 441 F.2d 579, 584, 169 USPQ 388, 392 (9th Cir.), *cert. denied*, 404 U.S. 887 [171 USPQ 322] (1971)).

The jury having found by special verdicts that Suzuki acted fraudulently, the requisite intent was established. "We give the trial judge and jury wide discretion in assessing punitive damages." *Hatrock v. Edward D. Jones & Co.*, 750 F.2d 767, 772 (9th Cir. 1984). The jury's award was not "so disproportionate to the damages sustained as to be the result of passion or prejudice". *Id.* (citing *Neal*, 21 Cal. 3d at 928, 582 P.2d at 990, 148 Cal. Rptr. at 399). *Transgo, Inc.*, 768 F.2d at 1024 [227 USPQ at 610] ("We will not overturn such an award unless it appears that the jury was influenced by passion or prejudice.") (citing *Harmsen v. Smith*, 693 F.2d 932, 947 (9th Cir. 1982), *cert. denied*, 464 U.S. 822 (1983)).

We answer the certified question that, in this case, neither a new trial nor judgment n.o.v. was warranted. The order of a new trial on this issue is vacated. The judgment on the jury verdicts of fraud and the award of compensatory and punitive damages is reinstated.

VII

The Tamaki Patent

Richardson states that Suzuki fraudulently patented the Alternate Shock Mount that had been disclosed to Suzuki by Richardson and Cazort in a patent that also described the "criss-cross" modification developed at Suzuki. There was evidence and argument on the factual premises, including the absence of supporting documentation on the part of the named inventors Hirohide Tamaki and Manabu Suzuki, the earliest record on their behalf being dated October 1979. The corresponding Japanese patent application was filed on October 16, 1979.

The jury rendered the following special verdicts:

> C-3. Did Suzuki and/or Mr. Tamaki file the Tamaki patent application in the knowledge that the invention asserted therein (the spring/swing arm connection) was first disclosed to them by Richardson:

Answer: YES

H-1. Do you find that the Plaintiff, Richardson, is the real inventor of the invention shown in the Tamaki patents and patent applications?

Answer: NO

It was not significantly disputed at trial that claims 1 through 8 of the Tamaki corresponding United States Patent No. 4,457,393 cover the Alternate Shock Mount of Richardson and Cazort, and that claim 9 includes the criss-cross embodiment of Tamaki and Suzuki. (The scope of claim 5 is raised, but is not material to our conclusion.)

The district court denied Richardson's post-trial motion that the Tamaki patent be assigned to Richardson. In colloquy with counsel the court explained that it could not do so because "the jury said Richardson wasn't the inventor". Indeed it was conceded, and discussed at trial, that Richardson and Cazort, not Richardson alone, invented the Alternate Shock Mount. Cazort, as well as Richardson, testified at length on this structure. Special verdict H-1 that Richardson is not "the real inventor" is in accord with the co-inventor status of Cazort, and also with the Japanese contribution of the criss-cross embodiment.

[12] The force of special verdict C-3 is not diminished. This verdict was not challenged on appeal. "It was further the duty of the court to direct the appropriate judgment to be entered upon the special verdict." *Traders and General Insurance Co. v. Mallitz*, 315 F.2d 171, 175 (5th Cir. 1963). The district court having failed to implement this verdict, Richardson's motion for judgment and for assignment of the Tamaki patents was not out of order.

The remedy of assignment of the Tamaki patents is a different question from whether Richardson is a sole or joint inventor. The correction of inventorship is an administrative step, and is not before the court. Similarly, the presence of a further modification in one or two claims of the patent directed to the Alternate Shock Mount does not negate the imposition of an equitable remedy. To hold otherwise would ratify and indeed reward the wrongdoing.

Based on the jury verdict, Richardson is entitled to ownership of the patents as against Suzuki. Such remedy is appropriate under the circumstances; *see, e.g., Colgate-Palmolive Co. v. Carter Products, Inc.*, 230 F.2d 855, 865, 108 USPQ 383, 391 (4th Cir.), *cert. denied*, 352 U.S. 843 [111 USPQ 467] (1956) (corporate assignee of patent application ordered to assign to original holder of trade secrets all rights to patent applications based thereon); *De Long Corp. v. Lucas*, 176 F.Supp. 104, 134 [122 USPQ 471, 493] (S.D.N.Y. 1959), *aff'd*, 278 F.2d 804 [125 USPQ 370] (2nd Cir.), *cert. denied*, 364 U.S. 833 [127 USPQ 555] (1960) (when an employee has acquired patents on inventions developed by his former employer, "the courts will hold the wrongdoer to be a constructive trustee of the property misappropriated and will order a conveyance by the wrongdoer to the former employer"); *Becher v. Contoure Laboratories, Inc.*, 279 U.S. 388 (1929) (same); *Saco-Lowell Shops v. Reynolds*, 141 F.2d 587, 598, 61 USPQ 3, 13 (4th Cir. 1944) (requiring assignment of patent based on ideas received by licensee from licensor in confidence during development of invention for market).

Suzuki argues that Richardson has no remedy other than by seeking an interference in the United States Patent and Trademark Office with his own invention, and presumably by taking similar actions, if such are available, in other countries. We do not agree. The courts are not powerless to redress wrongful appropriation of intellectual property by those subject to the courts' jurisdiction.

The denial of Richardson's motion for judgment is reversed. Suzuki shall assign to Richardson the patents filed by Suzuki that include the Richardson/Cazort invention of the Alternate Shock Mount, in all countries. We remand to the district court for the purpose of implementing compliance.

VIII

Prejudgment Interest

[13] The district court denied Richardson's request for prejudgment interest on both the patent infringement and the trade secret damage awards. Prejudgment interest is the rule governing this class of award. *General Motors Corp. v. Devex Corp.*, 461 U.S. 648, 655, 217 USPQ 1185, 1188 (1983); *Lummus Industries, Inc. v. D.M. & E. Corp.*, 862 F.2d 267, 274, 8 USPQ2d 1983, 1988 (Fed. Cir. 1988); *Fromson*, 853 F.2d at 1573-74, 7 USPQ2d at 1611; *Bio-Rad Laboratories, Inc. v. Nicolet Instrument Corp.*, 807 F.2d 964, 967, 1 USPQ2d 1191, 1193 (Fed. Cir. 1986), *cert. denied*, 107 S.Ct. 3187 (1987).

No exceptional circumstances having been shown, and no reason why damages for misappropriated trade secrets should be treated differently from damages for patent infringement, the denial of prejudgment interest is reversed.

IX

Willful Infringement and Exceptional Case

The district court refused to submit the question of willful infringement to the jury, stating that Richardson had not provided sufficient evidence to go to the jury.

To refuse to give an issue to the jury is to direct a verdict in favor of the opposing party. Thus we review the district court's ruling on the standard of "whether the evidence permits only one reasonable conclusion after viewing the evidence in the light most favorable to the non-moving party and drawing all inferences in favor of that party." *Bulgo v. Munoz*, 853 F.2d 710, 714 (9th Cir. 1988) (citing *Peterson v. Kennedy*, 771 F.2d 1244, 1256 (9th Cir. 1985), *cert. denied*, 475 U.S. 1122 (1986)). *See also Connell*, 722 F.2d at 1546, 220 USPQ at 197.

[14] Richardson refers to the evidence adduced in connection with the jury verdicts of fraud, to the verdicts of misappropriation of trade secrets 5 and 6, to the absence of any opinion of United States counsel concerning validity of the '332 patent when Suzuki started its infringing activity, and to evidence from Suzuki's records tending to show bad faith. Viewing this evidence in the light most favorable to Richardson, and drawing all reasonable inferences in his favor, there was sufficient evidence to take to the jury, for the evidence does not require a verdict in favor of Suzuki. Absent sufficient basis for directing the verdict, Richardson has the right of jury determination of this factual question. Willfulness of behavior is a classical jury question of intent. *Shiley*, 794 F.2d at 1568, 230 USPQ at 115; *Hammerquist v. Clarke's Sheet Metal, Inc.*, 658 F.2d 1319, 1325–26, 212 USPQ 481, 486 (9th Cir. 1981), *cert. denied*, 460 U.S. 1052 (1983). When trial is had to a jury, the issue should be decided by the jury.

We remand for this purpose. The jury's findings on the issue of willfulness will be pertinent not only to the question of multiplication of damages under 35 U.S.C. §284, but also to determination of whether this is an exceptional case in terms of 35 U.S.C. §285. Entitlement under California Civil Code §3426 may also be considered.

X

Other Arguments

Both sides have raised many points in their briefs, disputing most aspects of the proceedings. We have considered all arguments in reaching our conclusions.

Costs

[15] The award by the trial court of only one third costs to Richardson, in view of the judgments in his favor on the major substantive issues, exceeded the trial court's discretionary authority. Richardson is entitled to his statutory costs incurred before the district court. The reduction thereof is reversed.

Costs on this appeal are taxed in favor of Richardson.

AFFIRMED IN PART, REVERSED IN PART, VACATED IN PART, AND REMANDED.

Pennsylvania Superior Court

Den-Tal-Ez Inc. v. Siemens Capital Corp.

No. 02312 Philadelphia 1987

Decided October 21, 1988

TRADEMARKS AND UNFAIR TRADE PRACTICES

1. Trade secrets — In general (§400.01)

Mutual non-disclosure agreement, executed between plaintiff dental handpiece company and defendant that was negotiating to acquire plaintiff, which requires confidential information to be so marked but which does not define "confidential" information as limited only to information that is marked does not therefore limit its protections only to information marked "confidential."

2. Unfair competition — In general (§395.01)

Trade secrets — In general (§400.01)

Execution of confidentiality agreement does not thereby constitute implied waiver of common law protections against misappropriation of trade secrets.

3. Trade secrets — In general (§400.01)

Starting point under Pennsylvania law for determining whether alleged misappropriation of trade secret occurred is not whether confidential relationship existed but whether, in fact, trade secret existed which could be misappropriated, since Pennsylvania follows "property" view of trade secrets which shifts emphasis from whether defendant's conduct conformed to its confidential relationship with plaintiff to close analysis of whether information was trade secret.

products so that they can be positioned to enter the general market at the end of the lives of relevant patents. At least for relatively small start-up companies like Ventritex, where much of the business and technical work essential to survival is done by a small group of people, the promise by Congress of a safe haven could prove to be completely illusory if the courts permitted competitors to proceed full bore with expensive, resource-draining, and personnel-distracting litigation in the form of actions for declaratory relief. It makes little sense, and thus we assume would be inconsistent with Congress' intent, to protect companies like Ventritex from suit for actual patent infringement but leave them fully exposed to declaratory relief actions whose gravamen and burdens are much the same. While the considerations discussed in the preceding paragraph are sufficient to support our decision not to exercise jurisdiction at this time over plaintiff's declaratory relief counts, the fact that these additional policy considerations cut in the same direction intensifies our resolve.

For all the reasons discussed in this section, we hereby GRANT defendants' motion to dismiss plaintiff's declaratory relief claims (Counts VIII and IX). Those Counts are ORDERED dismissed.

V. DEFENDANTS' MOTION TO DISMISS THE REMAINING STATE LAW CLAIMS (COUNTS X - XIX)

Defendants earlier moved this court to dismiss plaintiff's state law claims asserted in Counts X - XVII of plaintiff's original complaint. Defendants contended that, since the sole basis of subject matter jurisdiction over these claims was pendency to the federal question claims in Counts I - IX, the court should dismiss the state law claims if it grants defendants' motion to dismiss the federal law claims in counts I - IX.

However, plaintiff has since amended its complaint. The second amended complaint now alleges a separate basis for jurisdiction under 28 U.S.C. § 1332(a) (diversity). Plaintiff also has added two new counts, including an additional federal claim (Count XVIII — Correction of Inventorship) that is not disposed of by our ruling on the applicability of the 271(e)(1) defense. Thus, we hereby DENY defendants' motion to dismiss plaintiff's state law claims.

VI. CONCLUSION

Given the dispositive effect of the 271(e)(1) defense on Counts I - IX of plaintiff's second amended complaint, this court finds that there is no just reason for delaying final judgment on those counts, despite the remaining federal law count and the state law counts. Thus, we ORDER entry of summary judgment on Counts I - IX.

IT IS SO ORDERED.

Court of Appeals, Federal Circuit

In re Vaeck

No. 91-1120

Decided October 21, 1991

PATENTS

1. Patentability/Validity — Obviousness — Combining references (§115.0905)

Rejection of claimed subject matter as obvious under 35 USC 103 in view of combination of prior art references requires consideration of whether prior art would have suggested to those of ordinary skill in art that they should make claimed composition or device, or carry out claimed process, and whether prior art would also have revealed that such person would have reasonable expectation of success; both suggestion and reasonable expectation of success must be founded in prior art, not in applicant's disclosure.

2. Patentability/Validity — Obviousness — Relevant prior art — Particular inventions (§115.0903.03)

Patent and Trademark Office has failed to establish prima facie obviousness of claims for use of genetic engineering techniques for producing proteins that are toxic to insects such as larvae of mosquitos and black flies, since prior art does not disclose or suggest expression in cyanobacteria of chimeric gene encoding insecticidally active protein, or convey to those of ordinary skill reasonable expectation of success in doing so; expression of antibiotic resistance-conferring genes in cyanobacteria, without more, does not render obvious expression of unrelated genes in cyanobacteria for unrelated purposes.

3. Patentability/Validity — Specification — Enablement (§115.1105)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Judicial review — Standard of review — Patents (§410.4607.09)

Specification must, in order to be enabling as required by 35 USC 112, first paragraph, teach person skilled in art to make and use

invention without "undue experimentation," which does not preclude some experimentation; enablement is question of law which is reviewed independently on appeal, although such determination is based upon underlying factual findings which are reviewed for clear error.

PATENTS

4. Patentability/Validity — Specification — Enablement (§115.1105)

Patent and Trademark Office did not err in rejecting, as non-enabling pursuant to 35 USC 112, first paragraph, claims for use of genetic engineering techniques for producing proteins that are toxic to insects such as larvae of mosquitos and black flies, in view of relatively incomplete understanding of biology of cyanobacteria as of applicants' filing date, as well as limited disclosure by applicants of particular cyanobacterial genera operative in claimed invention, since there is no reasonable correlation between narrow disclosure in applicants' specification and broad scope of protection sought in claims encompassing gene expression in any and all cyanobacteria.

Appeal from the U.S. Patent and Trademark Office, Board of Patent Appeals and Interferences.

Application for patent, serial no. 07/021,405, filed March 4, 1987, by Mark A. Vaeck, Wipa Chungjatupornchai, and Lee McIntosh (hybrid genes incorporating a DNA fragment containing a gene coding for an insecticidal protein, plasmids, transformed cyanobacteria expressing such protein and method for use as a biocontrol agent). From decision rejecting claims 1–48 and 50–52 as unpatentable under 35 USC 103, and rejecting claims 1–48 and 50–51 for lack of enablement, applicants appeal. Affirmed and part and reversed in part; Mayer, J., dissents with opinion.

Ian C. McLeod, Okemos, Mich., for appellant.

Teddy S. Gron, associate solicitor (Fred E. McKelvey, solicitor and Richard E. Schafer, associate solicitor, with him on brief), for appellee.

Before Rich, Archer, and Mayer, circuit judges.

Rich, J.

This appeal is from the September 12, 1990 decision of the Patent and Trademark Office (PTO) Board of Patent Appeals and Interferences (Board), affirming the examiner's rejection of claims 1-48 and 50-52 of application Serial No. 07/021,405, filed March 4, 1987, titled "Hybrid Genes Incorporating a DNA Fragment Containing a Gene Coding for an Insecticidal Protein, Plasmids, Transformed Cyanobacteria Expressing Such Protein and Method for Use as a Biocontrol Agent" as unpatentable under 35 USC 103, as well as the rejection of claims 1-48 and 50-51 under 35 USC 112, first paragraph, for lack of enablement. We reverse the § 103 rejection. The § 112 rejection is affirmed in part and reversed in part.

BACKGROUND

A. *The Invention*

The claimed invention is directed to the use of genetic engineering techniques [1] for production of proteins that are toxic to insects such as larvae of mosquitos and black flies. These swamp-dwelling pests are the source of numerous human health problems, including malaria. It is known that certain species of the naturally-occurring *Bacillus* genus of bacteria produce proteins ("endotoxins") that are toxic to these insects. Prior art methods of combatting the insects involved spreading or spraying crystalline spores of the insecticidal *Bacillus* proteins over swamps. The spores were environmentally unstable, however, and would often sink to the bottom of a swamp before being consumed, thus rendering this method prohibitively expensive. Hence the need for a lower-cost method of producing the insecticidal *Bacillus* proteins in high volume, with application in a more stable vehicle.

As described by appellants, the claimed subject matter meets this need by providing for the production of the insecticidal *Bacillus* proteins within host cyanobacteria. Although both cyanobacteria and bacteria are members of the procaryote [2] kingdom, the

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[1] Basic vocabulary and techniques for gene cloning and expression have been described in *In re O'Farrell*, 853 F.2d 894, 895-99, 7 USPQ2d 1673, 1674-77 (Fed. Cir. 1988), and are not repeated here.

[2] All living cells can be classified into one of two broad groups, procaryotes and eucaryotes. The procaryotes comprise organisms formed of cells that do not have a distinct nucleus; their DNA floats throughout the cellular cytoplasm. In contrast, the cells of eucaryotic organisms such as man, other animals, plants, protozoa, algae and yeast have a distinct nucleus wherein their DNA resides.

cyanobacteria (which in the past have been referred to as "blue-green algae") are unique among procaryotes in that the cyanobacteria are capable of oxygenic photosynthesis. The cyanobacteria grow on top of swamps where they are consumed by mosquitos and black flies. Thus, when *Bacillus* proteins are produced within transformed [3] cyanobacterial hosts according to the claimed invention, the presence of the insecticide in the food of the targeted insects advantageously guarantees direct uptake by the insects.

More particularly, the subject matter of the application on appeal includes a chimeric (i.e., hybrid) gene comprising (1) a gene derived from a bacterium of the *Bacillus* genus whose product is an insecticidal protein, united with (2) a DNA promoter effective for expressing [4] the *Bacillus* gene in a host cyanobacterium, so as to produce the desired insecticidal protein.

The claims on appeal are 1-48 and 50-52, all claims remaining in the application. Claim 1 reads:

> 1. A chimeric gene capable of being expressed in Cyanobacteria cells comprising:
> (a) a DNA fragment comprising a promoter region which is effective for expression of a DNA fragment in a Cyanobacterium; and
> (b) at least one DNA fragment coding for an insecticidally active protein produced by a Bacillus strain, or coding for an insecticidally active truncated form of the above protein or coding for a protein having substantial sequence homology to the active protein,
> the DNA fragments being linked so that the gene is expressed.

Claims 2-15, which depend from claim 1, recite preferred *Bacillus* species, promoters, and selectable markers.[5] Independent claim 16 and claims 17-31 which depend therefrom are directed to a hybrid plasmid vector which includes the chimeric gene of claim 1. Claim 32 recites a bacterial strain. Independent claim 33 and claims 34-48 which depend therefrom recite a cyanobacterium which expresses the chimeric gene of claim 1. Claims 50-51 recite an insecticidal composition. Claim 52 recites a particular plasmid that appellants have deposited.

B. *Appellants' Disclosure*

In addition to describing the claimed invention in generic terms, appellants' specification discloses two particular species of *Bacillus* (*B. thuringiensis, B. sphaericus*) as sources of insecticidal protein, and nine genera of cyanobacteria (*Synechocystis, Anacystis, Synechococcus, Agmenellum, Aphanocapsa, Gloecapsa, Nostoc, Anabaena* and *Ffremyllia*) as useful hosts.

The working examples relevant to the claims on appeal detail the transformation of a single strain of cyanobacteria, i.e., *Synechocystis* 6803. In one example, *Synechocystis* 6803 cells are transformed with a plasmid comprising (1) a gene encoding a particular insecticidal protein ("B.t. 8") from *Bacillus thuringiensis* var. *israelensis*, linked to (2) a particular promoter, the P_L promoter from the bacteriophage Lambda (a virus of *E. coli*). In another example, a different promoter, i.e., the *Synechocystis* 6803 promoter for the rubisco operon, is utilized instead of the Lambda P_L promoter.

C. *The Prior Art*

A total of eleven prior art references were cited and applied, in various combinations, against the claims on appeal.

The focus of Dzelzkalns,[6] the primary reference cited against all of the rejected claims, is to determine whether chloroplast promoter sequences can function in cyanobacteria. To that end Dzelzkalns discloses the expression in cyanobacteria of a chimeric gene comprising a chloroplast promoter sequence fused to a gene encoding the enzyme chloramphenicol acetyl transferase (CAT).[7] Importantly, Dzelzkalns teaches the use of the CAT gene as a "marker" gene; this use of antibiotic resistance-conferring genes for selection purposes is a common technique in genetic engineering.

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[3] "Transformed" cyanobacteria are those that have successfully taken up the foreign *Bacillus* DNA such that the DNA information has become a permanent part of the host cyanobacteria, to be replicated as new cyanobacteria are generated.

[4] "Expression" of a gene refers to the production of the protein which the gene encodes; more specifically, it is the process of transferring information from a gene (which consists of DNA) via messenger RNA to ribosomes where a specific protein is made.

[5] In the context of the claimed invention, "selectable markers" or "marker genes" refer to antibiotic-resistance conferring DNA fragments, attached to the gene being expressed, which facilitate the selection of successfully transformed cyanobacteria.

[6] 12 *Nucleic Acids Res.* 8917 (1984).

[7] Chloramphenicol is an antibiotic; CAT is an enzyme which destroys chloramphenicol and thus imparts resistance thereto.

Sekar I,[8] Sekar II,[9] and Ganesan [10] collectively disclose expression of genes encoding certain *Bacillus* insecticidal proteins in the bacterial hosts *B. megaterium, B. subtilis* and *E. coli*.

Friedberg [11] discloses the transformation of the cyanobacterium *Anacystis nidulans* R2 by a plasmid vector comprising the $O_L P_L$ operator-promoter region and a temperature-sensitive repressor gene of the bacteriophage Lambda. While the cyanobacteria are attractive organisms for the cloning of genes involved in photosynthesis, Friedberg states, problems may still be encountered such as suboptimal expression of the cloned gene, detrimental effects on cell growth of overexpressed, highly hydrophobic proteins, and rapid turnover of some gene products. To address these problems, Friedberg teaches the use of the disclosed Lambda regulatory signals in plasmid vehicles which, it states, have "considerable potential for use as vectors the expression of which can be controlled in *Anacystis*. . . ."

Miller [12] compares the initiation specificities *in vitro* of DNA-dependent RNA polymerases [13] purified from two different species of cyanobacteria (*Fremyella diplosiphon* and *Anacystis nidulans*), as well as from *E. coli*.

Nierzwicki-Bauer [14] identifies in the cyanobacterium *Anabaena* 7120 the start site for transcription of the gene encoding *rbcL*, the large subunit of the enzyme ribulose-1, 5-bisphosphate carboxylase. It reports that the nucleotide sequence 14-8 base pairs preceding the transcription start site "resembles a good *Escherichia coli* promoter," but that the sequence 35 base pairs before the start site does not.

Chauvat [15] discloses host-vector systems for gene cloning in the cyanobacterium *Synechocystis* 6803, in which the antibiotic resistance-conferring *neo* gene is utilized as a selectable marker.

Reiss [16] studies expression in *E. coli* of various proteins formed by fusion of certain foreign DNA sequences with the *neo* gene.

Kolowsky [17] discloses chimeric plasmids designed for transformation of the cyanobacterium *Synechococcus* R2, comprising an antibiotic-resistant gene linked to chromosomal DNA from the *Synechococcus* cyanobacterium.

Barnes, United States Patent No. 4,695,455, is directed to the treatment with stabilizing chemical reagents of pesticides produced by expression of heterologous genes (such as those encoding *Bacillus* proteins) in host microbial cells such as *Pseudomonas* bacteria. The host cells are killed by this treatment, but the resulting pesticidal compositions exhibit prolonged toxic activity when exposed to the environment of target pests.

D. *The Grounds of Rejection*

1. The § 103 Rejections

Claims 1-6, 16-21, 33-38, 47-48 and 52 (which include all independent claims in the application) were rejected as unpatentable under 35 USC 103 based upon Dzelzkalns in view of Sekar I or Sekar II and Ganesan. The examiner stated that Dzelzkalns discloses a chimeric gene capable of being highly expressed in a cyanobacterium, said gene comprising a promoter region effective for expression in a cyanobacterium operably linked to a structural gene encoding CAT. The examiner acknowledged that the chimeric gene and transformed host of Dzelzkalns differ from the claimed invention in that the former's structural gene encodes CAT rather than insecticidally active protein. However, the examiner pointed out, Sekar I, Sekar II, and Ganesan teach genes encoding insecticidally active proteins produced by *Bacillus*, and the advantages of expressing such genes in heterologous [18] hosts to obtain larger quantities of the protein. The examiner contended that it would have been obvious to one of ordinary skill in the art to substitute the *Bacillus* genes taught by Sekar I, Sekar II, and Ganesan for the CAT gene in the vectors of Dzelzkalns in order to obtain high level expression of the *Bacillus* genes in the transformed cyanobacteria. The examiner further contended that it would have been obvious to use cyanobacteria as heterologous hosts for expression of the claimed genes due to the ability of cyanobacteria to serve as transformed hosts for the

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[8] 137 *Biochem. and Biophys. Res. Comm.* 748 (1986).
[9] 33 *Gene* 151 (1985).
[10] 189 *Mol. Gen. Genet.* 181 (1983).
[11] 203 *Mol. Gen. Genet.* 505 (1986).
[12] 140 *J. Bacteriology* 246 (1979).
[13] RNA polymerase, the enzyme responsible for making RNA from DNA, binds at specific nucleotide sequences (promoters) in front of genes in DNA, and then moves through the gene making an RNA molecule that includes the information contained in the gene. Initiation specificity is the ability of the RNA polymerase to initiate this process specifically at a site(s) on the DNA template.
[14] 81 *Proc. Natl. Acad. Sci. USA* 5961 (1984).
[15] 204 *Mol. Gen. Genet.* 185 (1986).
[16] 30 *Gene* 211 (1984).
[17] 27 *Gene* 289 (1984).
[18] Denotes different species or organism.

expression of heterologous genes. In the absence of evidence to the contrary, the examiner contended, the invention as a whole was prima facie obvious.

Additional rejections were entered against various groups of dependent claims which we need not address here. All additional rejections were made in view of Dzelzkalns in combination with Sekar I, Sekar II, and Ganesan, and further in view of other references discussed in Part C above.

The Board affirmed the § 103 rejections, basically adopting the examiner's Answer as its opinion while adding a few comments. The legal conclusion of obviousness does not require absolute certainty, the Board added, but only a reasonable expectation of success, citing *In re O'Farrell*, 853 F.2d 894, 7 USPQ2d 1673 (Fed. Cir. 1988). In view of the disclosures of the prior art, the Board concluded, one of ordinary skill in the art would have been motivated by a reasonable expectation of success to make the substitution suggested by the examiner.

2. The § 112 Rejection

The examiner also rejected claims 1-48 and 50-51 under 35 USC 112, first paragraph, on the ground that the disclosure was enabling only for claims limited in accordance with the specification as filed. Citing *Manual of Patent Examining Procedure* (MPEP) provisions 706.03(n) [19] and (z) [20] as support, the examiner took the position that undue experimentation would be required of the art worker to practice the claimed invention, in view of the unpredictability in the art, the breadth of the claims, the limited number of working examples and the limited guidance provided in the specification. With respect to unpredictability, the examiner stated that

> [t]he cyanobacteria comprise a large and diverse group of photosynthetic bacteria including large numbers of species in some 150 different genera including *Synechocystis, Anacystis, Synechococcus, Agmenellum, Nostoc, Anabaena,* etc. The molecular biology of these organisms has only recently become the subject of intensive investigation and this work is limited to a few genera. Therefore the level of unpredictability regarding heterologous gene expression in this large, diverse and relatively poorly studied group of procaryotes is high.

The Board affirmed, noting that "the limited guidance in the specification, considered in light of the relatively high degree of unpredictability in this particular art, would not have enabled one having ordinary skill in the art to practice the broad scope of the claimed invention without undue experimentation. *In re Fisher*, 427 F.2d 833, 166 USPQ 18 (CCPA 1970)."

OPINION

A. *Obviousness*

We first address whether the PTO erred in rejecting the claims on appeal as prima facie obvious within the meaning of 35 USC 103. Obviousness is a legal question which this court independently reviews, though based upon underlying factual findings which we review under the clearly erroneous standard. *In re Woodruff*, 919 F.2d 1575, 1577, 16 USPQ2d 1934, 1935 (Fed. Cir. 1990).

[1] Where claimed subject matter has been rejected as obvious in view of a combination of prior art references, a proper analysis under § 103 requires, *inter alia*, consideration of two factors: (1) whether the prior art would have suggested to those of ordinary skill in the art that they should make the claimed composition or device, or carry out the claimed process; and (2) whether the prior art would also have revealed that in so making or carrying out, those of ordinary skill would have a reasonable expectation of success. *See In re Dow Chemical Co.*, 837 F.2d 469, 473, 5 USPQ2d 1529, 1531 (Fed. Cir. 1988). Both the suggestion and the reasonable expectation of success must be founded in the prior art, not in the applicant's disclosure. *Id.*

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[19] MPEP 706.03(n), "Correspondence of Claim and Disclosure," provides in part:

> In chemical cases, a claim may be so broad as to not be supported by [the] disclosure, in which case it is rejected as unwarranted by the disclosure. . . .

[20] MPEP 796.03(z), "Undue Breadth," provides in part:

> [I]n applications directed to intentions in arts were the results are unpredictable, the disclosure of a single species usually does not provide an adequate basis to support generic claims. *In re Sol*, 1938 C.D. 723; 497 O.G. 546. This is because in arts such as chemistry it is not obvious from the disclosure of one species, what other species will work. *In re Dreshfield*, 1940 C.D. 351; 518 O.G. 255 gives this general rule: "It is well settled that in cases involving chemicals and chemical compounds, which differ radically in their properties it must appear in an applicant's specification either by the enumeration of a sufficient number of the members of a group or by other appropriate language, that the chemicals or chemical combinations included in the claims are capable of accomplishing the desired result." . . .

[2] We agree with appellants that the PTO has not established the prima facie obviousness of the claimed subject matter. The prior art simply does not disclose or suggest the expression in cyanobacteria of a chimeric gene encoding an insecticidally active protein, or convey to those of ordinary skill a reasonable expectation of success in doing so. More particularly, there is no suggestion in Dzelzkalns, the primary reference cited against all claims, of substituting in the disclosed plasmid a structural gene encoding *Bacillus* insecticidal proteins for the CAT gene utilized for selection purposes. The expression of antibiotic resistance-conferring genes in cyanobacteria, without more, does not render obvious the expression of unrelated genes in cyanobacteria for unrelated purposes.

The PTO argues that the substitution of insecticidal *Bacillus* genes for CAT marker genes in cyanobacteria is suggested by the secondary references Sekar I, Sekar II, and Ganesan, which collectively disclose expression of genes encoding *Bacillus* insecticidal proteins in two species of host *Bacillus* bacteria (*B. megaterium* and *B. subtilis*) as well as in the bacterium *E. coli*. While these references disclose expression of *Bacillus* genes encoding insecticidal proteins in certain transformed *bacterial* hosts, nowhere do these references disclose or suggest expression of such genes in transformed *cyanobacterial* hosts.

To remedy this deficiency, the PTO emphasizes similarity between bacteria and cyanobacteria, namely, that these are both procaryotic organisms, and argues that this fact would suggest to those of ordinary skill the use of cyanobacteria as hosts for expression of the claimed chimeric genes. While it is true that bacteria and cyanobacteria are now both classified as procaryotes, that fact alone is not sufficient to motivate the art worker as the PTO contends. As the PTO concedes, cyanobacteria and bacteria are not identical; they are classified as two separate divisions of the kingdom Procaryotae.[2] Moreover, it is only in recent years that the biology of cyanobacteria has been clarified, as evidenced by references in the prior art to "blue-green algae." Such evidence of recent uncertainty regarding the biology of cyanobacteria tends to rebut, rather than support, the PTO's position that one would consider the cyanobacteria effectively interchangeable with bacteria as hosts for expression of the claimed gene.

At oral argument the PTO referred to additional secondary references, not cited against any independent claim (i.e., Friedberg, Miller, and Nierzwicki-Bauer), which it contended disclose certain amino acid sequence homology between bacteria and cyanobacteria. The PTO argued that such homology is a further suggestion to one of ordinary skill to attempt the claimed invention. We disagree. As with the Dzelzkalns, Sekar I, Sekar II, and Ganesan references discussed above, none of these additional references disclose or suggest that cyanobacteria could serve as hosts for expression of genes encoding *Bacillus* insecticidal proteins. In fact, these additional references suggest as much about *differences* between cyanobacteria and bacteria as they do about similarities. For example, Nierzwicki-Bauer reports that a certain nucleotide sequence (i.e., the -10 consensus sequence) in a particular cyanobacterium resembles an *E. coli* promoter, but that another nearby nucleotide sequence (the -35 region) does not. While Miller speaks of certain promoters of the bacteriophage Lambda that are recognized by both cyanobacterial and *E. coli* RNA polymerases, it also discloses that these promoters exhibited differing strengths when exposed to the different polymerases. Differing sensitivities of the respective polymerases to an inhibitor are also disclosed, suggesting differences in the structures of the initiation complexes.

The PTO asks us to agree that the prior art would lead those of ordinary skill to conclude that cyanobacteria are attractive hosts for expression of any and all heterologous genes. Again, we can not. The relevant prior art does indicate that cyanobacteria are attractive hosts for expression of both native and heterologous *genes involved in photosynthesis* (not surprisingly, for the capability of undergoing oxygenic photosynthesis is what makes the cyanobacteria unique among procaryotes). However, these references do not suggest that cyanobacteria would be equally attractive hosts for expression of *unrelated* heterologous genes, such as the claimed genes encoding *Bacillus* insecticidal proteins.

In *O'Farrell*, this court affirmed an obviousness rejection of a claim to a method for

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[2] *Stedman's Medical Dictionary* 1139 (24th ed. 1982) (definition of "Procaryotae"). Procaryotic organisms are commonly classified according to the following taxonomic hierarchy: Kingdom; Division; Class; Order; Family; Genus; Species. 3 *Bergey's Manual of Systematic Bacteriology* 1601 (1989).

producing a "predetermined protein in a stable form" in a transformed bacterial host. 853 F.2d at 895, 7 USPQ2d at 1674. The cited references included a prior art publication (the Polisky reference) whose three authors included two of the three coinventor-appellants. The main difference between the prior art and the claim at issue was that in Polisky, the heterologous gene was a gene for ribosomal RNA, while the claimed invention substituted a gene coding for a predetermined protein. *Id.* at 901, 7 USPQ2d at 1679. Although, as the appellants therein pointed out, the ribosomal RNA gene is not normally translated into protein, Polisky mentioned preliminary evidence that the transcript of the ribosomal RNA gene was translated into protein, and further predicted that if a gene coding for a protein were to be substituted, extensive translation might result. *Id.* We thus affirmed, explaining that

> the prior art explicitly suggested the substitution that is the difference between the claimed invention and the prior art, and presented preliminary evidence suggesting that the [claimed] method could be used to make proteins.
>
> . . . .
>
> . . . Polisky contained detailed enabling methodology for practicing the claimed invention, a suggestion to modify the prior art to practice the claimed invention, and evidence suggesting that it would be successful.

Id. at 901-02, 7 USPQ2d at 1679-80.

In contrast with the situation in *O'Farrell*, the prior art in this case offers no suggestion, explicit or implicit, of the substitution that is the difference between the claimed invention and the prior art. Moreover, the "reasonable expectation of success" that was present in *O'Farrell* is not present here. Accordingly, we reverse the § 103 rejections.

B. *Enablement*

[3] The first paragraph of 35 USC 112 requires, *inter alia*, that the specification of a patent enable any person skilled in the art to which it pertains to make and use the claimed invention. Although the statute does not say so, enablement requires that the specification teach those in the art to make and use the invention without "undue experimentation." *In re Wands*, 858 F.2d 731, 737, 8 USPQ2d 1400, 1404 (Fed. Cir. 1988). That *some* experimentation may be required is not fatal; the issue is whether the amount of experimentation required is "undue." *Id.* at 736-37, 8 USPQ2d at 1404. Enablement, like obviousness, is a question of law which we independently review, although based upon underlying factual findings which we review for clear error. *See id.* at 735, 8 USPQ2d at 1402.

In response to the § 112 rejection, appellants assert that their invention is "pioneering," and that this should entitle them to claims of broad scope. Narrower claims would provide no real protection, appellants argue, because the level of skill in this art is so high, art workers could easily avoid the claims. Given the disclosure in their specification, appellants contend that any skilled microbiologist could construct vectors and transform many different cyanobacteria, using a variety of promoters and *Bacillus* DNA, and could easily determine whether or not the active *Bacillus* protein was successfully expressed by the cyanobacteria.

The PTO made no finding on whether the claimed invention is indeed "pioneering," and we need not address the issue here. With the exception of claims 47 and 48, the claims rejected under § 112 are not limited to any particular genus or species of cyanobacteria. The PTO's position is that the cyanobacteria are a diverse and relatively poorly studied group of organisms, comprising some 150 different genera, and that heterologous gene expression in cyanobacteria is "unpredictable." Appellants have not effectively disputed these assertions. Moreover, we note that only one particular species of cyanobacteria is employed in the working examples of appellants' specification, and only nine genera of cyanobacteria are mentioned in the entire document.

[4] Taking into account the relatively incomplete understanding of the biology of cyanobacteria as of appellants' filing date, as well as the limited disclosure by appellants of particular cyanobacterial genera operative in the claimed invention, we are not persuaded that the PTO erred in rejecting claims 1-46 and 50-51 under § 112, first paragraph. There is no reasonable correlation between the narrow disclosure in appellants' specification and the broad scope of protection sought in the claims encompassing gene expression in any and all cyanobacteria. *See In re Fisher*, 427 F.2d 833, 839, 166 USPQ 18, 24 (CCPA 1970) (the first paragraph of § 112 requires that the scope of the claims must bear a reasonable correlation to the scope of enablement provided by the specifi-

cation).[22] Accordingly, we affirm the § 112 rejection as to those claims.

In so doing we do *not* imply that patent applicants in art areas currently denominated as "unpredictable" must never be allowed generic claims encompassing more than the particular species disclosed in their specification. It is well settled that patent applicants are not required to disclose every species encompassed by their claims, even in an unpredictable art. *In re Angstadt*, 537 F.2d 498, 502-03, 190 USPQ 214, 218 (CCPA 1976). However, there must be sufficient disclosure, either through illustrative examples or terminology,[23] to teach those of ordinary skill how to make and how to use the invention as broadly as it is claimed. This means that the disclosure must adequately guide the art worker to determine, without undue experimentation, which species among all those encompassed by the claimed genus possess the disclosed utility. Where, as here, a claimed genus represents a diverse and relatively poorly understood group of microorganisms, the required level of disclosure will be greater than, for example, the disclosure of an invention involving a "predictable" factor such as a mechanical or electrical element. *See Fisher*, 427 F.2d at 839, 166 USPQ at 24. In this case, we agree with the PTO that appellants' limited disclosure does not enable one of ordinary skill to make and use the invention as now recited in claims 1-46 and 50-51 without undue experimentation.

Remaining dependent claim 47 recites a cyanobacterium which expresses the chimeric gene of claim 1, wherein the cyanobacterium is selected from among the genera *Anacystis* and *Synechocystis*. Claim 48, which depend from claim 47, is limited to the cyanobacterium *Synechocystis* 6803. The PTO did not separately address these claims, nor indicate why they should be treated in the same manner as the claims encompassing all types of cyanobacteria. Although these claims are not limited to expression of genes encoding particular *Bacillus* proteins, we note what appears to be an extensive understanding in the prior art of the numerous *Bacillus* proteins having toxicity to various insects. The rejection of claims 47-48 under § 112 will not be sustained.

CONCLUSION

The rejection of claims 1-48 and 50-52 under 35 USC 103 is *reversed*. The rejection of claims 1-46 and 50-51 under 35 USC 112, first paragraph, is *affirmed* and the rejection of claims 47 and 48 thereunder is *reversed*.

AFFIRMED-IN-PART, REVERSED-IN-PART

Mayer, J., dissenting.

An appeal is not a second opportunity to try a case or prosecute a patent application, and we should not allow parties to "undertake to retry the entire case on appeal." *Perini America, Inc. v. Paper Converting Machine Co.*, 832 F.2d 581, 584, 4 USPQ2d 1621, 1624 (Fed. Cir. 1987); *Eaton Corp. v. Appliance Valves Corp.*, 790 F.2d 874, 877, 229 USPQ 668, 671 (Fed. Cir. 1986). But that is precisely what the court has permitted here. The PTO conducted a thorough examination of the prior art surrounding this patent application and concluded the claims would have been obvious. The board's decision based on the examiner's answer which comprehensively explains the rejection is persuasive and shows how the evidence supports the legal conclusion that the claims would have been obvious. Yet, the court ignores all this and conducts its own examination, if you will, as though the examiner and board did not exist. Even if I thought this opinion were more persuasive than the board's, I could not join it because it misperceives the role of the court.

The scope and content of the prior art, the similarity between the prior art and the claims, the level of ordinary skill in the art, and what the prior art teaches are all questions of fact. *Graham v. John Deere Co.*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966); *Jurgens v. McKasy*, 927 F.2d 1552, 1560, 18 USPQ2d 1031, 1037 (Fed. Cir. 1991). And "[w]here there are two permissible views of

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[22] The enablement rejection in this case was not based upon a post-filing date state of the art, as in *In re Hogan*, 559 F.2d 595, 605-07, 194 USPQ 527, 536-38 (CCPA 1977). *See also United States Steel Corp. v. Phillips Petroleum Co.*, 865 F.2d 1247, 1251, 9 USPQ2d 1461, 1464 (Fed. Cir. 1989) (citing *Hogan*); *Hormone Research Found., Inc. v. Genentech, Inc.*, 904 F.2d 1558, 1568-69, 15 USPQ2d 1039, 1047-48 (Fed. Cir. 1990) (directing district court, on remand, to consider effect of *Hogan* and *United States Steel* on the enablement analysis of *Fisher*), *cert. dismissed*, ____ U.S. ____, 111 S. Ct. 1434 (1991). We therefore do not consider the effect of *Hogan* and its progeny on *Fisher*'s analysis of when an inventor should be allowed to "dominate the future patentable inventions of others." *Fisher*, 427 F.2d at 839, 166 USPQ at 24.

[23] The first paragraph of § 112 requires nothing more than *objective* enablement. *In re Marzocchi*, 439 F.2d 220, 223, 169 USPQ 367, 369 (CCPA 1971). How such a teaching is set forth, either by the use of illustrative examples or by broad terminology, is irrelevant. *Id.*

the evidence, the factfinder's choice between them cannot be clearly erroneous." *Anderson v. City of Bessemer City*, 470 U.S. 564, 574 (1985). The mere denomination of obviousness as a question of law does not give the court license to decide the factual matters afresh and ignore the requirement that they be respected unless clearly erroneous. *In re Woodruff*, 919 F.2d 1575, 1577, 16 USPQ2d 1934, 1935 (Fed. Cir. 1990); *In re Kulling*, 897 F.2d 1147, 1149, 14 USPQ2d 1056, 1057 (Fed. Cir. 1990). There may be more than one way to look at the prior art, but on this record we are bound by the PTO's interpretation of the evidence because it is not clearly erroneous and its conclusion is unassailable. I would affirm on that basis.

Court of Appeals, Federal Circuit

Biocraft Laboratories Inc. v. International Trade Commission

Nos. 91-1153, 1208
Decided October 17, 1991

PATENTS

1. U.S. International Trade Commission — Remedies (§155.07)

JUDICIAL PRACTICE AND PROCEDURE

Procedure — Settlement agreements; consent decrees (§410.43)

REMEDIES

Non-monetary and injunctive — Equitable relief — Preliminary injunctions — Bond (§505.0707.03)

International Trade Commission abused its discretion by refusing to release bond posted by respondent to 19 USC 1337 complaint in compliance with temporary cease and desist order, even though respondent made sales of infringing product during effective period of order, since complainant authorized sales in question and agreed to return of bond as part of settlement agreement with respondent, since bond provisions, under terms of order, do not apply to sales authorized by complainant, and since public interest in vindicating rights of patentees, as well as complainant's interest in offsetting competitive advantage respondent obtained by importing infringing product, were satisfied by complainant's agreement to return of bond and thus would not be furthered by retention of bond by ITC.

Appeal from the U.S. International Trade Commission.

U.S. International Trade Commission investigation no. 337-TA-293, instituted in response to complaint of Bristol-Meyers Co., now Bristol-Meyers Squibb Co., against, inter alia, Biocraft Laboratories Inc., for violation of Tariff Act's Section 337, 19 USC 1337. From order denying in part respondent's request for return or cancellation of two bonds posted in compliance with temporary cease and desist order, and from order denying respondent's request for reconsideration of prior order, respondent appeals. Reversed.

Prior decision: 15 USPQ2d 1258.

Marc S. Gross, of Bryan, Cave, McPheeters & McRoberts (Michael G. Biggers, Elizabeth C. Carver, David A. Roodman, and Elizabeth M. Garnhard, on brief), New York, N.Y., for appellant.

Marc A. Bernstein (Lyn Schlitt, general counsel, and James A. Toupin, assistant general counsel, on brief), for appellee.

Before Skelton, senior circuit judge, and Newman and Lourie, circuit judges.

Lourie, J.

This is a consolidated appeal from (1) an order of the United States International Trade Commission issued November 14, 1990, in *Crystalline Cefadroxil Monohydrate*, Inv. No. 337-TA-293, No. 91-1153, denying in part Biocraft Laboratories, Inc.'s request for return or cancellation of two bonds and (2) an order of the Commission issued January 11, 1991, Inv. No. 337-TA-293, No. 91-1208, denying Biocraft's request for reconsideration of the prior order. Because we conclude that the Commission's denial of Biocraft's requests was an abuse of discretion, we *reverse*.

BACKGROUND

This appeal stems from an investigation begun by the Commission in response to a complaint and motion for temporary relief filed by the Bristol-Myers Company[1] on February 1, 1989. In the complaint, Bristol

[1] The Bristol-Myers Company has since become the Bristol-Myers Squibb Company.